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FIGURES

APPENDICES

1.0 SCOPE.

1.1 Identification. This Segment Specification establishes the performance, design, development, and qualification requirements for the Network Expansion Low Level Wind Shear Alert System (LLWAS). The LLWAS system includes the Remote Stations, the Master Station, and System Displays. This system will be configurable for up to twenty-two Remote Stations.

1.2 System Overview. The Network Expansion LLWAS will be installed at major airports to detect the presence of hazardous wind shear. The Master Station Controller processes information provided from wind sensors using special algorithms that will identify the degree of severity of windshear events (Microburst or Windshear) and the location with respect to the operational runway. In addition to current windshear alerts, the centerfield and threshold winds are displayed.

1.3 Document Overview. This specification provides functional, performance, development, qualification, and quality assurance requirements for the LLWAS, and is organized as follows:

Section 1 includes the identification of this specification, the purpose of LLWAS, and the introduction.

Section 2 lists documents applicable for the LLWAS requirements described in this specification.

Section 3 contains functional, performance, interface, and system characteristics, processing resources, quality factors, logistics, precedence requirements, and qualification requirements. The major functional areas are organized into the states and modes in which they operate and include the following areas:

a.) Real Time

b.) Support

This functional breakdown is not intended to imply a specific design for the LLWAS system. Design will be the responsibility of the Contractor except where design requirements are provided by the Government.

Section 4 lists quality assurance requirements.

Section 5 lists requirements for preparations for delivery of the system, including packing and shipping considerations.

Section 6 contains the mission, intended use for LLWAS, and acronym list.

2.0 APPLICABLE DOCUMENTS.

2.1 Government Documents. The following documents of the issue in effect on the date of request for proposals or invitation for bids form a part of this specification and are applicable to the extent described in this document. In the event of conflict between the documents referenced herein and the contents of this specification, the latter shall be considered a superseding requirement.

SPECIFICATIONS:

Federal Aviation Administration

FAA-G-2100	Electronics Equipment, General Requirements
FAA-G-1210	Provisioning Technical Documentation
FAA-G-1375	Spare Parts-Peculiar for Electronic Electrical, and Mechanical Equipment

STANDARDS:

Federal

FED-STD-1003	Synchronous Bit Oriented Data Link Control Procedures

FAA

FAA-STD-019A	Lightning Grounding, Protection Bonding, and Shielding Requirements for Facilities
FAA-STD-020	Transient Protection, Grounding, Bonding, and Shielding for Equipment
FAA-STD-024	Preparation of Test and Evaluation Documentation
FAA-STD-028	Contract Training Program
FAA-D-2494	Technical Instruction Book Manuscript

Military

DOD-STD-1686	Electrostatic Discharge Control

	Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment
DOD-STD-2167	Defense System Software Development
DOD-D-100	Engineering Drawing Practices
MIL-STD-108	Definitions of and Basic Requirements for Enclosures for Electric and Electronic Equipment
MIL-STD-129	Marking for Shipment and Storage
MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements
MIL-STD-462	Measurements of Electromagnetic Interface Characteristics
MIL-STD-470	Maintainability Program Requirements for Systems and Equipment
MIL-STD-280	Definition of Item Level, Item Exchangeability, Models and Related Terms
MIL-STD-785	Reliability Program for Systems and Equipment Development and Production
MIL-STD-794	Parts and Equipment, Procedures for Packaging of
MIL-STD-810	Environmental Test Methods and Engineering Guidelines
DOD-D-1000	Drawings, Engineering and Associated Lists
MIL-STD-1189	Bar Coding Symbology, Standards, DOD
MIL-STD-1388-1	Logistic Support Analysis
MIL-STD-1388-2	DOD Requirements for a Logistic Support Record
MIL-STD-1561	Provisioning Procedures, Uniform

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MIL-STD-1388-2	DOD Requirements for a Logistic Support Record
MIL-STD-1561	Provisioning Procedures, Uniform

STANDARDS:

EIA-530	High Speed 25-Position Interface Data Terminal Equipment and Data Circuit-Terminating Equipment
EIA-RS-232	Interface between Data Terminal Equipment and Data Communications Equipment Employing Serial Binary Data Interchange.
ANSI X3.4-1977	American National Standard Code for Information Interchange
ANSI X3.66	American National Standard for Advanced Data Communications Control Procedure (ADCCP)

OTHER PUBLICATIONS:

NEC-NFPA-70	National Electrical Code (NEC)

2.3 Public Documents. The following documents of the issue in effect on the date of request for proposals or invitation for bids form a part of this specification and are applicable to the extent described in this document. In the event of conflict between the contents of this specification and the documents referenced herein, the latter shall be considered a superseding requirement.

FCC Rules, Part 15, Subpart J	Rules and Regulations, Radio Frequency Devices/Computing Devices
OSHA	Occupational Safety and Health Act, (29 CFR 1910)

3.0 SYSTEM REQUIREMENTS.

3.1 Definition. The Network Expansion LLWAS comprises a system of hardware and software that provides realtime collection of wind data and processing to detect the presence of hazardous windshear in the vicinity of an airport and provide the location of the hazard relative to the runways.

3.1.1 Functional Areas. The functional areas of LLWAS are:

a.) Data Collection. Wind field data is collected by sensors at the Remote Stations and transmitted to the Master Station Controller. The data is archived before further analysis.

b.) Analysis. Wind field data is analyzed using algorithms utilizing Temporal Shear, Divergence and Network Mean methods to determine if any elements (stations, edges, or triangles) are in alarm.

c.) Microburst or Windshear Alert Generation. The element alarms are processed with respect to the runways to determine location and magnitude of hazardous windshear. Persistent windshear conditions result in runway alert generation.

d.) Air Traffic Controller (ATC) Display. All runway alerts, centerfield winds and gust, runway threshold winds, and system status are displayed to the Controllers.

e.) Remote Monitoring Subsystem (RMS). The LLWAS RMS system provides status, remote control via the Maintenance Processing Subsystem (MPS) and local control via the Maintenance Data Terminal.

The functional relationships and the transformation of data are shown in figure 1.

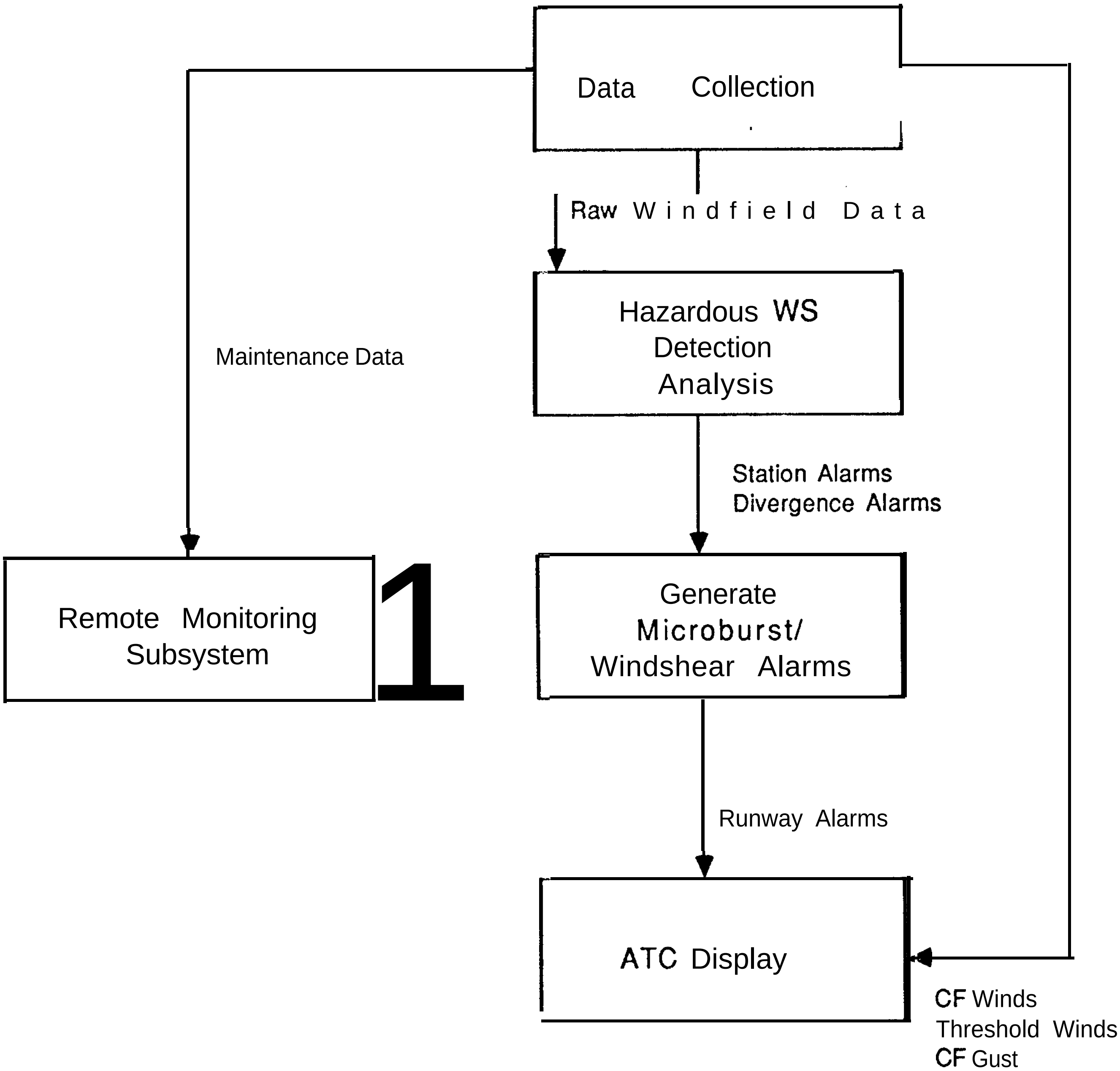

Figure 1 LLWAS Functional Data Flow

3.1.2 Operational Requirements. The basic operational requirements of LLWAS are to:

a.) Provide low level hazardous windshear detection.

b.) Provide measurement of the level of windshear hazard and its location.

c.) Provide automation of windshear hazard detection.

d.) Provide centerfield wind measurements.

e.) Provide runway threshold wind measurements.

f.) Provide a clear direct transmission of the windshear hazard information, centerfield and runway threshold wind measurements to the local and approach air traffic controllers for provision to the aviation user.

(Refer to Appendix B for definitions of windshear and associated terms).

3.1.3 Equipment Configuration. The LLWAS configuration consists of the following components:

3.1.3.1 Existing Equipment

FA 10240 and FA 10240/1

Anemometer	095-89-00004
Display, PWA	205-89-03419
Tower Display Terminals	253-C3736-00
System Assembly (Master Station)	253-C3563-02
System Assembly (Remote Station)	434-C0984-04
TRACON Display Assembly	435-89-00026
Display, PWA (Optional)	205-89-03419

FA 10239

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FA 10239

2.) System Support State shall be distributed between two modes; Local and Remote.

c.) The state and mode of operation shall determine the respective system capabilities and their functions as follows:

1.) Real Time modes shall share similar capabilities of data collection, hazardous windshear detection processing, data storage, ATC display, support, and maintenance. Initialization and Degraded modes shall have a subset of Normal mode capability functions and their own unique functions. (Refer to paragraphs 3.2.1.1.1, 3.2.1.1.2, and 3.2.1.1.3).

2.) The capabilities in the System Support State are in the Local mode, where the RMS shall operate independently from the Maintenance Processor Subsystem (MPS), or in the Remote mode, where all maintenance and support activities shall be controlled by the MPS. (Refer to paragraph 3.2.1.2).

(Refer to Figure 2 for an illustration of this architecture. The transition between the different states and modes is shown in Figure 3.)

(Refer to paragraph 3.2.2 for Real Time and System Support capability relationships.)

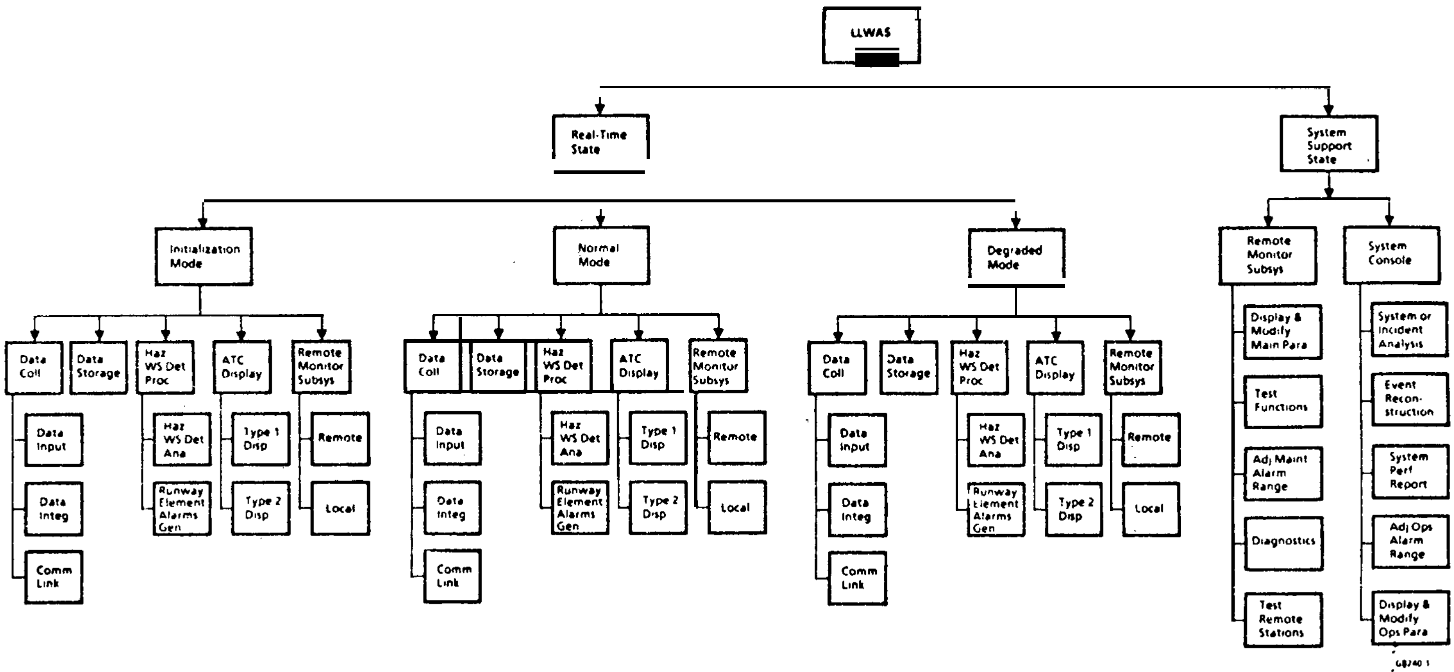

Figure 2 1 L WAS Functional Structure

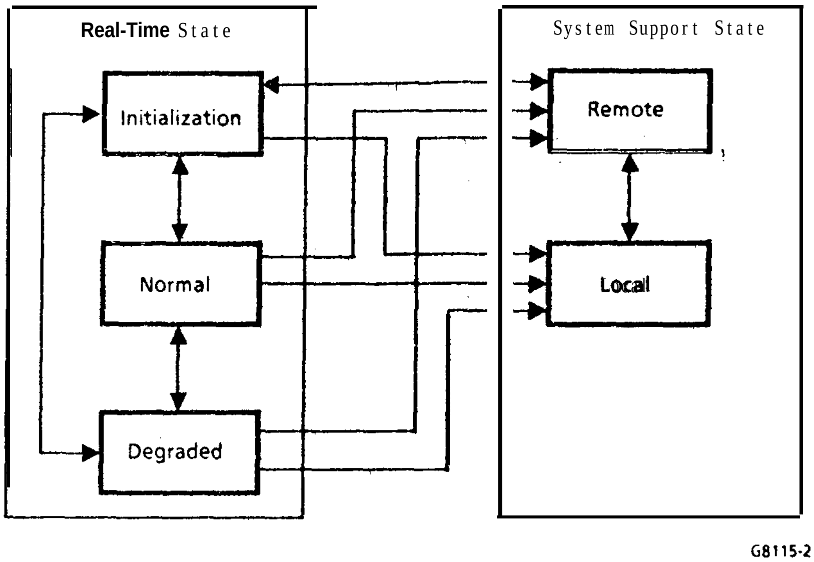

Figure 3 States and Modes Transitional Relationships

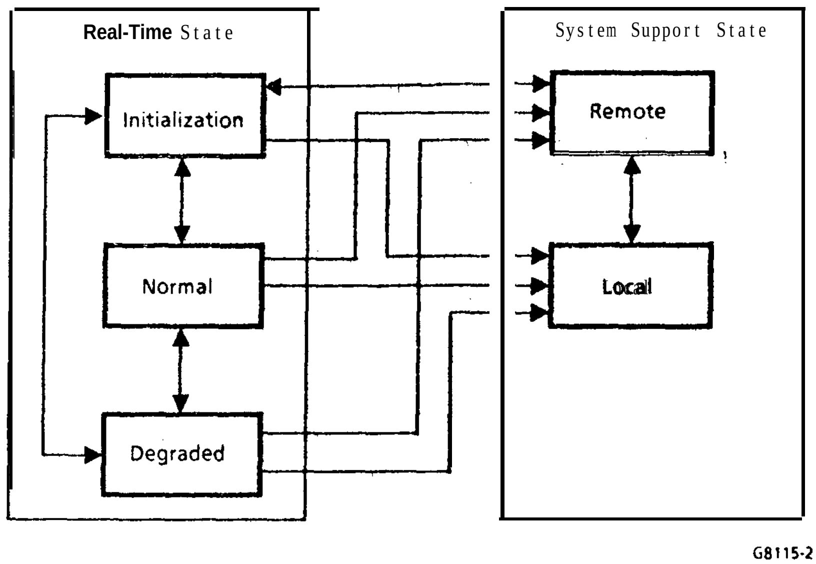

Figure 3 States and Modes Transitional Relationships

Remote Stations for retrieval at the request of the Master Station for validation and further processing.

a.) A Remote Station shall be the group of equipment located at one of the configured sites on or near the airport from which all wind data is measured and retrieved from. Station locations will be dependent on the airport geometry, and siting information will be provided in the Government furnished files. (Refer to Appendix C for contents of Government furnished files). Poles with sensor mounting surfaces will be furnished by the Government.

b.) When RF transmission is used the installation for remote sensors shall insure line-of-sight transmission between the Remote Stations and the Master Station. All modifications shall be approved by the Government.

c.) There shall be up to a maximum of 22 Remote stations per airport.

d.) The Master Station shall consist of the Master Station Controller and associated equipment located at the ATC Tower which performs all the functions of the LLWAS system with the exception of wind measurement and Remote Station maintenance monitoring.

3.2.1.1.1.1.1 Data Input. Wind data shall be collected from all remote stations by the Master Station during each scan cycle.

3.2.1.1.1.1.1.1 Wind data. Wind data shall originate as wind speed and direction measured by a sensor at a Remote Station. In addition, the Remote Station which is the Centerfield (CF) sensor shall provide gust speed.

a.) Wind data shall be converted to a wind velocity vector, pointed in the direction of the wind flow (u,v). The unit of measurement shall be expressed in meters/second with positive v directed to magnetic north and positive u directed to (magnetic) east.

b.) Accuracy of the wind direction measured by sensor (excludes effects from pole placement and sensor mounting which are supplied by the Government) shall be +/- 2.5 degrees.

c.) Accuracy of the wind speed measured by sensor (excludes effects from pole placement and sensor mounting which are supplied by the Government) shall be +/- two knots for speeds from zero to ninety-nine knots.

3.2.1.1.1.1.1.2 Scan Cycle. A scan cycle shall be the interrogation and response process repeated once per station for all configured remote stations.

a.) An interrogation with response process shall consist of the following:

1.) A request shall be sent to one remote station from the master station for wind data.

2.) The request shall be retried untill valid wind data is received or discontinued to allow for data collection from other sensors.

b.) A soft transmission failure shall be reported to RMS for each retry.

c.) If the scan cycle cannot be completed within the time allocated to meet the throughput requirements of ten seconds, (paragraph 3.2.1.1.1a and 3.2.1.1.1b), the scan cycle shall be terminated and the system shall enter a Network Failure condition. (Refer to paragraph 3.2.1.1.3 for a description of Network Failure.)

d.) The scan shall run continuously, with no lapse of time separating cycles.

(Refer to paragraphs 3.2.1.1.3.1.1 for hard error handling.)

3.2.1.1.1.1.2 Data Integrity. Data shall be validated at both the remote and master stations for format and content.

a.) A format or content error detected by the Master Station Controller shall initiate a retry of the query. (paragraph 3.2.1.1.1.1.1.2).

b.) A Soft Transmission Failure indication shall be recorded for the Remote Station with which the error occurred as specified in paragraph 3.2.1.1.1.1.1.2.

(Refer to paragraph 3.2.1.1.3.1.1 for a description of hard failure handling).

3.2.1.1.1.1.3 Communications Link. A data communication link shall be provided between the Master Station and Remote Stations.

a.) The link shall accommodate two-way half duplex communication over a maximum distance of ten miles between the Master Station and any Remote Station.

b.) The Bit Error Rate shall not exceed one error in 10^5 bits transmitted.

c.) If an RF link is utilized, the following requirements shall be met:

1.) Transmit and receive shall be on the same frequency.

2.) Frequency range shall be selectable between 406 Mhz - 420 Mhz and 160 Mhz - 172 Mhz.

3.) Government approval of specific frequency assignments shall be obtained for each link prior to installation of the link.

4.) Approval shall be obtained from the Government FAA Spectrum Engineering Division for maximum power transmitted for radiating equipment.

5.) A directional antenna shall be utilized for all remote stations.

6.) The transmitter levels shall be adjustable.

d.) If a RF link is not feasible due to line of sight problems or close proximity of the remote station to the master station an non-RF link (direct hard wire, modems, and Large Airport Cable Loop) shall be utilized.

3.2.1.1.1.2 Hazardous Windshear Detection Processing. Hazardous windshear and microbursts shall be detected and alarms generated, related to the runway.

a.) Hazardous Windshear Detection Processing shall begin after receipt of the last data from a scan cycle.

b.) Contents of the Government furnished files for each airport shall be used to provide the values for the parameters utilized by the hazardous wind shear detection and runway alarm generation algorithms described in the following paragraphs. (Refer to Appendix C for description of contents of the Government furnished files).

c.) Wind speed values of three knots or less shall be converted to zero knots (calm) prior to initiation of the Hazardous Windshear Detection Analysis process.

3.2.1.1.1.2.1 Hazardous Windshear Detection Analysis. Government furnished algorithms described in the following paragraphs, are contained in Appendix A. The algorithms shall be the method utilized to detect Windshear or Microbursts.

a.) Network Mean (NMN). Network Mean will be computed, and then stabilized by the use of a statistical outlier trimming strategy and averaged with the model parameters using filtering techniques. (Refer to Appendix A Section IV.)

b.) Temporal Shear (TS). Temporal Shear detection will be based upon the difference between slow and fast response low pass filters. To compensate for noise at each station, Temporal Shear variances will be estimated for use as normalizing factors. (Refer to Appendix A Section III.)

c.) Triangle and Edge Divergence (TED) Method. Hazardous windshear is indicated when calculated triangle or edge divergence exceeds thresholds. The effect of data noise will be reduced by filtering. The alarm threshold for an element will be adjusted based on the number of TS detections for that element. (Refer to Appendix A, Section V and VII).

d.) Station Shear Detection. A remote station will be in Shear when station winds are statistically different from the NMN winds. The effect of data noise will be reduced by filtering. Detection alarm thresholds will be adjusted at each station according to TS condition at that station. (Refer to Appendix A Section VI.)

3.2.1.1.1.2.2 Runway Element Alarm Generation. The generation of runway alarms shall be accomplished by utilizing the algorithms contained in Appendix A to transform station, edge or triangle alarm conditions into runway messages.

3.2.1.1.1.2.2.1 Persistence. Runway messages shall be sent for Type 1 display only if a wind shear condition for a runway persists for a parameter determined number of times. (Refer to Paragraph 3.2.1.1.1.4 for description of Type 1 display and Appendix C for a description of parameters),

3.2.1.1.1.2.2.2 Runway Messages. Runway messages shall indicate the type of alerts, threshold winds direction and speed, location of expected first encounter, runway oriented expected loss or gain, multiple windshears, and a possible windshear outside of network alert. The alerts shall indicate the presence of hazardous windshear.

a.) There are two types of messages: Microburst Alert (MBA), and Windshear Alert (WSA).

1.) Microburst Message. A MBA is issued when a Microburst is detected within the network.

A Microburst is a detected divergence with a loss estimate greater than or equal to a parameter determined level in knots (after rounding to the nearest 5 knots). Refer to Appendix C for a description of parameters, A microburst will always be a loss. (Refer to Appendix A, Section VIII)*

The runway loss estimate of an element is the product of the divergence estimate and the effective length of that element. The runway loss will be the largest loss associated with the runway. (Refer to Appendix A, section VIII, B.4).

2.) Windshear Alert. A WSA is issued if a shear condition is detected within the Network with runway oriented loss (ROL) or gain (ROG) exceeding a parameter determined level in knots. (Refer to Appendix A section IX for ROL and ROG definitions and Appendix C for a description of the parameters).

A shear condition is a weak divergence alarm of less than 25 knots (Refer to Appendix A, section VII), or a station anomaly (Refer to Appendix A, section VI).

b.) Runway Threshold Winds. The runway threshold winds indicate direction and speed of the winds at a sensor near the runway threshold. (Refer to Appendix C for description of threshold 'stations and assigned priorities).

c.) Alert Location. The location indicated by the alarm will be the first runway position where the event will be encountered. (Refer to Appendix C for description of the operational runway alert pointer table and Appendix A section XI).

d.) Runway Oriented Loss or Gain. Runway oriented loss or gain will be calculated by taking the maximum gain or loss differences for the associated runway. A runway oriented gain (ROG) is gain greater than the absolute loss value plus ten knots. A runway oriented loss (ROL) is the loss greater than a parameter determined level in knots except when the above criteria for gain is satisfied. In events where there are both gains and losses, only the more significant feature, which is normally the loss, will be reported. (Refer to Appendix A section IX).

e.) Possible Windshear Outside Of Network. Possible Windshear Outside Of Network message will be generated if an anomaly is received from any one of several network boundary stations (Refer to Appendix C, for a description of boundary stations and assigned priorities.) and a WSA exists for the runway to which the boundary station is associated. The resultant vector of the network boundary station winds minus the Network Mean, shall be directed into the network, along the runway axis. (Refer to Appendix A, Section X).

3.2.1.1.1.3 Storage. The following information shall be automatically stored in non-volatile memory for every scan cycle:

a.) Timestamp of scan cycle.

b.) Software failures. These failures shall include the following:

1.) Input or Output failures that occur within the applications software.

2.) Usage failures from interfaces with operating system services.

3.) Usage failures from interfaces with library utilities.

c.) Type 1 display terminal identification and indication of predefined runway configuration mask (as defined in appendix C) currently in use at that display.

d.) Status of all runways, to include windshear alerts, threshold winds, and runway messages.

e.) Maintenance and operational activities that change system operation. This information shall include activity identification and the operator logged on at the time of the activity.

f.) Hardware failure.

g.) The raw data (u,v) from each station.

3.2.1.1.1.3.1 Storage Capacity. There shall be sufficient capacity to accommodate the storage of the above data in non-volatile memory for sixty days.

3.2.1.1.1.3.2 Tape Backup. There shall be a tape backup with a minimum capacity to hold sixty days of data.

a.) Tape backups must be contiguous on tape.

b.) If data is dumped on to tape daily, the system outage time shall not exceed one minute.

c.) If data is dumped on to tape only once a month, the system outage time shall not exceed thirty minutes.

3.2.1.1.1.4 ATC Display. There shall be two types of ATC displays, Type 1 and Type 2 displays.

3.2.1.1.1.4.1 General Characteristics.

a.) Character Size and Brightness. Displayed information shall be clearly and easily read from a distance of ten feet in ambient lighting conditions varying from moonlight (0.01 foot candle) to shaft sunlight (10000 foot candles). The character size shall not be smaller than 0.25 inches in height with the exception of system and station failures and Microburst and Windshear Alert history messages which shall be less than 0.25 inches but greater than 0.125 inches

b.) Interconnection Cabling.

1.) For Type I displays the specified length shall be up to one thousand feet between the Master Station Controller and any display.

2.) For Type II displays the specified length shall be up to one thousand feet between the Master Station Controller and the first display. Other displays can be daisy chained up to 500 feet between displays.

3.2.1.1.1.4.2 Type 1 Displays. LLWAS information as specified in the following paragraphs shall be displayed at each local controller position.

3.2.1.1.1.4.2.1 Maximum Quantity of Type 1 Displays. The LLWAS shall support up to nine type 1 displays concurrently.

3.2.1.1.1.4.2.2 Alphanumeric Displays. The displays shall be alphanumeric.

3.2.1.1.1.4.2.3 Physical Constraints. The Type 1 displays shall have the following constraints:

a.) The display housing shall not exceed a width of eleven inches, a height of nine inches, and a depth of nine inches.

b.) The display shall be designed for flush mounting in an upwardly sloping console (with a slope of 10 to 75 degrees from horizontal).

3.2.1.1.1.4.2.4 Runway Configuration Screens. The runway configuration shall be displayed and changeable by the tower cab supervisor as needed, as indicated below:

a.) There shall be a local controller position that shall display, when selected by the tower cab supervisor, the entire operational runway configuration and associated LLWAS data for that airport.

b.) Each additional Type 1 display shall only display the runway configuration for a specific local controller position, (i.e. departure or arrival configuration).

c.) Predefined runway configurations shall be selectable from one input device located in the tower cab and available to the tower cab supervisor. Preprogrammed runway configurations will be provided as part of the adaptation parameters in the Government furnished files. (Refer to Appendix C for contents of Government furnished files).

3.2.1.1.1.4.2.5 Display Format. The following information shall be displayed:

a.) CF two minute average Wind Direction and Speed, and Gust:

1.) The CF average wind direction shall be in degrees, rounded to the nearest ten degrees, from ten to three hundred and sixty degrees (10 - 360). This shall be the indication of the direction from which the wind is blowing.

2.) The CF average wind speed shall be in knots, from three to ninety-nine (3 - 99) in one knot increments.

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2.) The CF average wind speed shall be in knots, from three to ninety-nine (3 - 99) in one knot increments.

1.) LA - left arrival
2.) LD - left departure
3.) RA - right arrival
4.) RD - right departure
5.) CA - center arrival
6.) CD - center departure
7.) A - arrival
8.) D - departure

b.) Threshold wind direction and speed information for that runway as follows:

1.) Threshold wind direction shall be in degrees, rounded to the nearest ten degrees, from ten to three hundred and sixty degrees (10 - 360). This shall be the indication of the direction from which the wind is blowing.

2.) The threshold wind speed shall be in knots, from three to ninety-nine (3 - 99) in one knot increments. Wind speed less than three knots shall be represented as calm.

3.2.1.1.1.4.2.5.2 Alert Status. For each line referenced in 3.2.1.1.1.4.2.5e that is in alert, the non-alert status (refer to para 3.2.1.1.1.4.2.5.1) and alert status shall be displayed. Alert status shall consist of runway designator and runway message.

a.) An alert message shall be displayed in inverse video.

b.) An alert message shall remain on the screen for five scan cycle after each occurrence.

c.) The runway designator and message shall be displayed as follows: (Refer to paragraph 3.2.1.1.1.2.2.2 for definition of runway message).

1.) Runway designator as described in paragraph 3.2.1.1.1.4.2.3.5a.

2.) Type of Alert. (Refer to paragraph 3.2.1.1.1.2.2.2a).

3.) Runway oriented loss or gain shall be expressed as the velocity in knots, from fifteen to ninety-five in five knot increments. The velocity shall be followed by a "K" followed by a plus or minus sign to indicate direction (refer to paragraph 3.2.1.1.1.2.2.2d for ROE and ROG definitions).

4.) Alert Location shall be expressed as "RWY" to indicate hazard on the designated physical runway, and "1MF", "2MF", "3MF" to indicate one, two and three, respectively, nautical mile(s) from final for an arrival configuration, and "1MD", "2MD", to indicate 1 or 2 nautical miles (nm) off the departure end of the runway for a departure configuration.

5.) "POS WS OTS" (Possible Windshear Outside of Network) message shall be displayed if a possible wind shear outside of network is detected. (Refer to paragraph 3.2.1.1.1.2.2.2e for definition of Possible Windshear Outside of Network).

6.) Threshold wind and direction as described in paragraph 3.2.1.1.1.4.2.5.1.b.

d.) There shall be a five second audible alert for every occurrence of an alert condition. The level shall be adjustable.

e.) If multiple Windshears or Micrbursts exist for an operational runway a message shall be displayed between the runway designator and the type of alert. The displayed message shall be "MULT". The loss or gain displayed shall be for strongest of the multiple Windshears and Microbursts. The displayed location shall be for the first of the multiple Windshears or Microbursts encountered.

3.2.1.1.1.4.2.6 Brightness and Contrast Controls. Brightness and contrast of displayed data shall be adjustable and accessible from the front of the display.

3.2.1.1.1.4.3 Type 2 Display. Type 2 displays shall provide LLWAS information as specified in the following paragraphs. There shall be a type II display available for use by the approach or departure controllers. The display requirements of 3.2.1.1.1.4.1.a shall apply.

3.2.1.1.1.4.3.1 Physical Constraints. The display housing shall not exceed a width of 8 1/16 inches, a height of 5 inches, and a depth of 12 inches.

3.2.1.1.1.4.3.2 Maximum Quantity of Type 2 Displays. The LLWAS shall support up to eight Type 2 displays concurrently. The specific number of Type 2 displays are determined by airport operational requirements, and will be furnished by the Government. (Refer to Appendix C for contents of the Government furnished files).

3.2.1.1.1.4.3.3 Display Format. Type 2 displays shall display only the average value of the CF wind speed and direction for the previous two minutes, and gust value as specified in paragraph 3.2.1.1.1.4.2.5a except the unit of measure for all values and "Gust" label shall not be displayed.

3.2.1.1.1.5 Remote Monitorins Subsystem. The LLWAS shall provide on-line management of system operations and maintenance functions via a Remote Monitoring Subsystem (RMS). (For off-line functions provided by the RMS refer to paragraph 3.2.1.2).

a.) On-line maintenance activities shall not degrade CPU and memory utilization by more than 10%, unless a change of state or mode request is performed.

b.) The functional requirements shall be as follows and in accordance with NAS-MD-793.

3.2.1.1.1.5.1 Categories of Operation. The RMS shall have two categories of operation:

a.) A Remote capability controlled by the Maintenance Processor subsystem (MPS).

b.) A Local capability independent from the MPS. Control shall be removed from the MPS and retained solely by the RMS via the Maintenance Data Terminal (MDT) while monitoring via the MPS continues.

3.2.1.1.1.5.2 RMS Organization. The RMS shall be part of the LLWAS and shall be included in the following components:

a.) Remote Station sensors and associated circuitry.

b.) Master Station Controller and non-volatile storage medium.

3.2.1.1.1.5.3 RMS Functions. The following functions shall be provided by the RMS. Unless otherwise stated, all functions shall be capable of being performed remotely and locally.

3.2.1.1.1.5.3.1 Monitoring. The RMS shall provide automatic monitoring of LLWAS performance data. As a minimum, performance parameters shall be provided to determine the operational status for all the LLWAS subsystems. The accuracy (total uncertainty from all causes) of each measurement shall be not more than 10% of the total acceptable band for the parameter. For example, if the acceptable band for a power supply is 4.5 to 5.5 volts, the RMS error must be less than 0.1 volts within that band.

3.2.1.1.1.5.3.2 Report Generation. Report generation and processing shall be provided and structured in accordance with message formats and interactive procedures specified in NAS-MD-790.

a.) The message report format shall be used for interaction for LLWAS command using the RMS MDT.

b.) Failure processing and reporting shall pre-empt and interrupt all other report processing. A verified alarm shall be generated and transmitted to the MPS on the next poll in accordance with NAS-MD-790.

c.) Failure reporting shall be disabled when maintenance is being performed in the local mode.

d.) Numerical data sent to the MPS shall require no additional processing other than ASCII conversion for display purposes and decimal point insertion (if required).

3.2.1.1.1.5.3.3 Failure Detection and Reporting. The RMS shall detect failure and state change conditions and automatically report the occurrence of each change or failure.

a.) The RMS shall generate a return to normal message after the condition is cleared.

b.) To avoid nuisance maintenance alarms a timer shall be started or restarted with the occurrence of each state change and failure. No new failures or state changes shall be reported while timer is in effect. The time duration of the timer shall be continuously adjustable from 1 to 30 seconds.

c.) The RMS shall have the capability to enable and disable reporting of all failures and state changes. An indication of that status shall be provided to the MPS.

c.) The RMS shall have the capability to report two levels of failures: soft maintenance alarms and hard maintenance alarms. After collecting an equipment's parameter values, LLWAS shall automatically compare the maintenance alarm threshold values for that parameter with the collected value. LLWAS shall establish, through this comparison, whether or not the parameter is within required operating limits, but outside a desired operating range (an indication of a soft maintenance alarm): or outside required operating limits (an indication of a hard maintenance alarm).

These maintenance alarms shall be reported to MPS and MDT.

d.) The RMS shall report any change in current status within two seconds average, ten maximum (99th percentile), measured from the time the status change occurs to the time the status message is ready for transmission.

e.) Maintenance alarms shall be retained in storage until the problem clears or they are reset by the MDT.

3.2.1.1.1.5.3.4 System Control. The RMS shall provide the capability to change the state and mode of the system on demand.

a.) Control capabilities shall allow the specialist (at the MPS and MDT) to:

1.) Change the active station configuration.

2.) Reset a maintenance alarm indication.

3.) Power down or up any subsystem of the LLWAS.

4.) Restart, start up, or terminate the real time state.

b.) The RMS shall complete control commands within two seconds average and five seconds maximum (99th percentile) measured from the time the command is received, to the time the command execution is completed.

3.2.1.1.1.5.3.5 Remote Station Diagnostics and Fault Isolation. The RMS shall provide, on demand, sufficient diagnostic and fault information to assist specialists in locating failing or failed LRUs at a remote station. The failed LRU shall be identified.

a.) The RMS shall acknowledge receipt of a valid test command to the requestor. The acknowledgment shall be reported within one second measured from the time the test command is received either from a remote or local console input port, until the time the test acknowledgement is queued at the port for transmission back to the requestor.

b.) The RMS shall collect and report test results within fifty seconds average and four minutes maximum (99th percentile) measured from the time the test request is received at the port until the test report is queued at the port for transmission back to the requestor.

c.) These diagnostics shall be capable of being remotely initiated by the MPS and MDT.

3.2.1.1.1.5.3.6 System Security. Access control shall be performed by the RMS to ensure proper user authorization prior to the execution of local capabilities.

3.2.1.1.1.5.3.7 Terminal Messages. The RMS shall provide for message routing between the MDT and MPS:

a.) The RMS in the Remote mode shall be capable of passing terminal message between the MDT and MPS without interpreting the message content (i.e. transparent pass-thru)

b.) In the local mode of operation, the MDT shall have control of LLWAS. Direct communication between MPS and MDT is inhibited to prevent incoming messages from interrupting the technician's work, displacing a screen he may be using to perform adjustments or diagnostics. The RMS shall notify the MDT that a message is waiting. The notification that a message is waiting will be displayed for 60 minutes or until operator requests message transfer.

c.) The RMS shall switch between local and remote modes upon receipt of MDT commands only. RMS shall default to the remote mode after 60 minutes of inactivity on the MDT interface.

3.2.1.1.2 Initialization Mode. Initialization shall be the mode during which Wind data shall be accumulated to build a sufficient historical basis from which stable estimates of statistical information are derived.

a.) The Initialization Mode shall be entered from any mode within Real Time State with the input of a restart command from RMS, or entry of a start command in the System Support State. Initialization shall only be entered automatically after initial power up of the system.

b.) This process shall have a duration of thirty scan cycles, to stabilize the Network Mean calculation in accordance with Appendix A section IV.B.1.

c.) This mode shall be successfully completed before the Normal Mode is entered. Transition to the Normal Mode shall be automatic upon successful completion of the Initialization Mode.

d.) Initialization shall be terminated at any time if there is manual intervention,(entry of a stop or restart command), power failure, or insufficient raw data available (more than half of the sensors are down). The system shall return to a System Support state in every case except for the entry of the restart command, at which time the Initialization process will be reinitiated.

e.) All capabilities shall function as specified in the Normal Mode (refer to paragraph 3.2.1.1.1), except for those processes that utilize the stabilized statistics, as described in the subsections that follow.

3.2.1.1.2.1 Data Collection. The scan cycle shall be initiated following the initialization of all data collection parameters. (Refer to Appendix C, for a list of parameters).

3.2.1.1.2.2 Hazardous Windshear Detection Processing. All functions shall operate as described in Normal Mode,. paragraph 3.2.1.1.1.2 , except as listed in the following subsections:

3.2.1.1.2.2.1 Hazardous Windshear Detection Analysis. Analysis of data shall occur as described in paragraph 3.2.1.1.1.2.1 except as detailed below:

a.) Temporal Shear. Estimates of Temporal Shear variances will be constructed, therefore Temporal Shear values will not be available as adjustment indicators to threshold values for Divergence, and Windshear detection calculations until Initialization has completed. (Refer to Appendix A, Section III).

b.) Triangle and Edge Divergence (TED) Method. During this start-up period, divergence values will not be calculated.

c.) Station Alarm Processing. Theses calculations will not be done during Initialization.

3.2.1.1.2.2.2 Runway Element Alarms Generation. Alarms shall not be issued at this time.

3.2.1.1.2.3 ATC Display. There shall not be any LLWAS information displayed until initialization has completed.

3.2.1.1.2.3.1 Initialization Message. A message shall be displayed during initialization indicating the status of the process.

3.2.1.1.3 Degraded Mode. The Degraded Mode shall consist of those conditions that result in less than 100% operability as defined in the Normal Mode, paragraph 3.2.1.1.1:

a.) Entry to this mode shall occur automatically as a response to a failure condition, or as a result of manual **reconfigurration.**

b.) The degraded mode shall terminate when the following actions occur:

1.) The system fully recovers 100% operability as defined in paragraph 3.2.1.1.1 and a Normal or Initialization Mode is entered.

2.) A Network Fail condition persists for longer than 4 or more Scan Cycles and the system transitions to a System Support state.

c.) The transition process, from a failed condition, shall be initiated automatically, upon subsystem availability, unless manually disabled, and regardless of the duration of the failure (except for long duration Network Failures).

1.) The transition to a normal mode after a long duration station failure shall not be complete until after 5 scan cycles have elapsed.

2.) If Network Fail condition persists for longer than 4 or more scan cycles, the system shall automatically transition to a System Support state.

d.) The conditions for Degraded Mode are listed below:

1.) Windshear detection not available for a runway. Less than the predetermined minimum number of remote stations required for reliable hazard detection processing (varies for each airport, defined in Appendix C) are active for an operational runway .

2.) Short Duration Network Fail. Fewer-than half of the configured stations will be active for the entire network for a duration less than 4 scan cycles, disallowing the majority of the analysis to be implemented.

Refer to paragraph 3.2.1.2 for the system status during a long duration Network Fail condition (4 scan cycles or more).

3.) Station Failure. The number of failed stations will be less than the number required for conditions 1 and 2 above.

a.) A short duration failure for a station shall be a down time of less than 4 scan cycles.

b.) A long duration failure shall be at least 4 scan cycles.

4.) Hardware subsystem error or failure, other than a remote station (which does not cause the entire system to fail).

5.) Software error (which does not cause the software to fail).

e.) A Remote Station is considered active when a message has been received with valid wind data in response to an interrogation.

3.2.1.1.3.1 Data Collection. The collection of data from active stations shall be uninterrupted by station or short duration network failure(s), and shall resume for failed stations as soon as data is available as follows:

3.2.1.1.3.1.1 Scan Cycle. A Hard Fail shall be reported to the RMS if the sampled data is unavailable or the error checking function reports an error for three sequential scan cycles from a Remote Station.

a.) Hard failure handling along with processing of data from active station shall support the requirement specified in paragraph 3.2.1.1.1a and 3.2.1.1.1b.

b.) After the report of a hard failure, the following action shall be performed:

1.) Repeated interrogation attempts over one scan cycle shall be discontinued.

2.) The station shall continue to be queried once per scan until data with correct format and content is received at the Master Station.

3.) The Master Station Controller shall then accept wind data for normal processing from the Remote Station during the next scan cycle.

3.2.1.1.3.2 Hazardous Windshear Detection Processing. All functions as described in paragraph 3.2.1.1.1.2, shall operate similarly, except as indicated in the following subparagraphs.

a.) At any time that there is a Network Failure, Hazardous Windshear Detection Analysis and alarm generation are discontinued.

3.2.1.1.3.2.1 Hazardous Windshear Detection Analysis. The analysis process shall function as described in the Normal Mode, paragraph 3.2.1.1.1.2.1, except for the functions indicated below:

a.) Time Series. After a short duration Station or Network failure, time series averages for u,v will be reinstated with the last values computed before failure. After a long duration station failure, time series will be reinitialized.

b.) Temporal Shear (TS). After a short duration station or network failure, filters for TS analysis will be reinstated with the last values computed. After a long duration station failure, TS time series are shortened to accelerate recovery.

c.) TED Method. This method will be implemented as described in Normal Mode, paragraph 3.2.1.1.1.2.1c with the exception of divergence will not be computed for any element that the failed station is associated with.

d.) Station Shear Detection. Station shear detection processing will function as described in paragraph 3.2.1.1.1.2.1d, with the following exceptions:

1.) After a Short Duration Station or Network Failure. Station variances will be reinstated with the last values computed.

1.) Repeated interrogation attempts over one scan cycle shall be discontinued.

2.) The station shall continue to be queried once per scan until data with correct format and content is received at the Master Station.

3.) The Master Station Controller shall then accept wind data for normal processing from the Remote Station during the next scan cycle.

3.2.1.1.3.2 Hazardous Windshear Detection Processing. All functions as described in paragraph 3.2.1.1.1.2, shall operate similarly, except as indicated in the following subparagraphs.

a.) At any time that there is a Network Failure, Hazardous Windshear Detection Analysis and alarm generation are discontinued.

3.2.1.1.3.2.1 Hazardous Windshear Detection Analysis. The analysis process shall function as described in the Normal Mode, paragraph 3.2.1.1.1.2.1, except for the functions indicated below:

a.) Time Series. After a short duration Station or Network failure, time series averages for u,v will be reinstated with the last values computed before failure. After a long duration station failure, time series will be reinitialized.

b.) Temporal Shear (TS). After a short duration station or network failure, filters for TS analysis will be reinstated with the last values computed. After a long duration station failure, TS time series are shortened to accelerate recovery.

c.) TED Method. This method will be implemented as described in Normal Mode, paragraph 3.2.1.1.1.2.1c with the exception of divergence will not be computed for any element that the failed station is associated with.

d.) Station Shear Detection. Station shear detection processing will function as described in paragraph 3.2.1.1.1.2.1d, with the following exceptions:

1.) After a Short Duration Station or Network Failure. Station variances will be reinstated with the last values computed.

c.) "Windshear Data Unavailable for Runway". Windshear unavailable message shall be displayed adjacent to remaining data on the line of the impacted runway.

3.2.1.1.3.4 Remote Monitoring Subsystem. All functions shall be consistent with those described in Normal Mode, paragraph 3.2.1.1.1.5.

3.2.1.2 System Support State.

a.) The System Support state shall be entered when any of the following actions occur:

1.) Power-up or reboot of the Master Station Controller.

2.) Long duration (greater than 4 scan cycles or more) Network Fail.

b.) The System Support State shall terminate when any of the following actions occur:

1.) The system is powered down.

2.) A start command is received from RMS.

c.) The RMS shall provide additional capabilities in the System Support state as well as retaining all functionality as specified in 3.2.1.1.1.5.

d.) The local System Console shall be used for system or incident analysis and event reconstruction.

3.2.1.2.1 Modes of Operation. The RMS shall operate in two modes; local and remote.

a.) Local Mode. The RMS shall be off line to the MPS and all functions, except monitoring from the MPS, shall be performed from the MDT.

b.) Remote Mode. The RMS shall perform maintenance and support functions under the control of the MPS .

3.2.1.2.2 RMS Capabilities. All capabilities of the RMS in the System Support state shall operate in either the Local or Remote mode, with the following exceptions:

a.) Any functions requiring the use of data contained on other than an internal LLWAS storage medium shall not be executable from a remote terminal.

b.) Site specific software parameters shall not be modifiable at a remote terminal, although they shall be displayable.

3.2.1.2.2.1 Display and Modify Software Maintenance Parameters. Software parameters (site specific, and global) shall be externally loadable from MDT or the MPS and displayable at the MDT or MPS for modification, as required. (Refer to Appendix C for a list of parameters).

3.2.1.2.2.2 Test Functions. The RMS shall have the capability to test in an off line state the LLWAS real time processing as follows:

a.) Simulated and real time wind data inputs, and keyboard commands shall be utilized.

b.) Test results shall be output to a data file in ASCII format from which data may be retrieved and displayed on the requesting terminal for evaluation, or output to a selected hardcopy or storage device.

3.2.1.2.2.3 Adjusting Maintenance Alarm Ranges. The RMS shall provide the capability to set or change ranges for system maintenance alarm parameters.

3.2.1.2.2.4 Diagnostics. The RMS shall be capable of performing diagnostic routines on all LLWAS subsystems.

3.2.1.2.2.5 Testing of All Remote Stations. The RMS shall have the capability to perform an all stations test that shall provide the following-information:

a.) Raw data, prior to any filtering, and data in its normally received form.

b.) Station number, values of u,v, Gust, and checksum.

c.) Message status (i.e. a message was not received from the station, station number was incorrect, the computed checksum was incorrect, bad parity, message properly received).

3.2.1.2.3 System Console. This application shall be used for following operational activities:

3.2.1.2.3.1 System or Incident Analysis. The system shall provide the capability to analyze system performance and perform event reconstructions for incident investigation, based on data extracted from data history files from tape or disk. Refer to paragraph 3.2.1.1.1.3 for a list of data history file contents.

3.2.1.2.3.1.1 Event Reconstruction. This utility shall generate a report to the requesting terminal of historical information in ASCII format from tape or disk, for output to a selected hardcopy or storage device.

a.) The report shall include both the source request and the extracted data.

b.) The following requests shall be accommodated:

1.) Provide hazardous windshear alerts by time and date or controller position or both.

2.) Display station or runway activity by time and date, any one specific activity such as Microburst and Windshear alerts, threshold winds, etc., or outages.

3.2.1.2.3.1.2 System Performance Summary. The System Console shall be capable of providing a summary of requested performance data for a selected time frame.

3.2.1.2.3.2 Adjusting Operational Alarm Ranges. The System Console shall provide the capability to set or change ranges for system operational alarm or alert parameters.

3.2.1.2.3.3 Display and Modify Software Operational Parameters. Software parameters (site specific, and global) shall be externally loadable from tape to disk files and displayable at the local terminal for modification, as required. (Refer to Appendix C for a list of parameters).

3.2.2 System Capability Relationships.

3.2.2.1 Real Time Capabilities. Each mode in the Real Time state shall share the same primary capabilities with some functional differences.

3.2.2.2 System Support Capabilities. The System Support state capabilities shall be mutually accessible from within this state.

3.2.3 External Interfaces. LLWAS has the following external interfaces:

a.) Maintenance Processor Subsystem (MPS).

b.) Remote Monitoring Subsystem Concentrator (RMSC).

c.) Tower Control Computer Complex (TCCC).

d.) Maintenance Data Terminal (MDT)

e.) Terminal Doppler Weather Radar (TDWR)

f.) External Time

g.) Pole mounts for remote sensors

Figure 4 depicts the interface relationships.

3.2.3.1 LLWAS to MPS Interface. This interface shall be in accordance with NAS-MD-790. The two basic requirements for this interface are:

a.) Maintenance and alarms are sent to the MPS. NAS-MD-790 allows for two levels of maintenance alarms, soft and hard.

b.) Status information at the request of MPS. MPS can ask for status and performance reports based on different combinations of Logical Units (LU).

c.) Bit-oriented data link procedures for synchronous communications shall be implemented

3.2.3.2 LLWAS to RMSC Interface. This interface shall be in accordance with NAS-MD-790.

3.2.3.3 LLWAS to TCCC Interface. If there is an interface to TDWR than this interface will not be required. There are following requirements for this interface:

a.) The LLWAS/TCCC interface shall be implemented per FED-STD-1003 (ANSI X3.66 - ADCCP), using Asynchronous Balanced Mode (ABM) and Option 2 (REJ). Errorred data blocks shall be discarded. Implementation with compatible HDLC (e.g., ISO 3309, 4335, and 7809) shall be acceptable.

b.) LLWAS shall interface to the DCE transmission equipment with an EIA-530 connector. Category I circuits shall accept timing from the DCE. LLWAS shall also implement Category II circuits: Local Loopback (circuit LL), Remote Loopback (circuit RL), and Test Mode (circuit TM).

3.2.3.4 LLWAS to MDT Interface. There shall be an interface to the MDT using as minimum the code for Information Interchange

Requirements ANSI X3.4-1977. The interface shall use 8 bits, no parity, and shall automatically adjust itself to the following baud rates:2400, 4800, 9600. The protocol (defined by the Government) shall be asynchronous and commercially available for the MDT. An EIA Standard RS-232C interface shall be used. The RS-232C plug shall be a DB 25 pin female and configured as DCE. An ICD will be created to describe this interface.

3.2.3.5 LLWAS to TDWR Interface. The interface shall consist of an EIA-530 serial asynchronous line. LLWAS shall be responsible for preparing the windfield data collected from the Remote Station for transmission to TDWR. There are following requirements for this interface:

a.) The LLWAS/TDWR interface shall be implemented per FED-STD-1003 (ANSI X3.66 - ADCCP), using Asynchronous Balanced Mode (ABM) and Option 2 (REJ). Errorred data blocks shall be discarded. Implementation with compatible HDLC (e.g., ISO 3309, 4335, and 7809) shall be acceptable.

b.) LLWAS shall interface to the DCE transmission equipment with an EIA-530 connector. Category I circuits shall accept timing from the DCE. LLWAS shall also implement Category II circuits: Local Loopback (circuit LL), Remote Loopback (circuit RL), and Test Mode (circuit TM).

3.2.3.6 LLWAS to External Time. The interface shall consist of a RS-232 serial synchronous line.

3.2.3.7 LLWAS to Pole Mounts for Remote Sensors. The anemometer and radio antenna will physically attach to the mounting ring assembly as described in the Specification for High Poles and National Construction Standards.

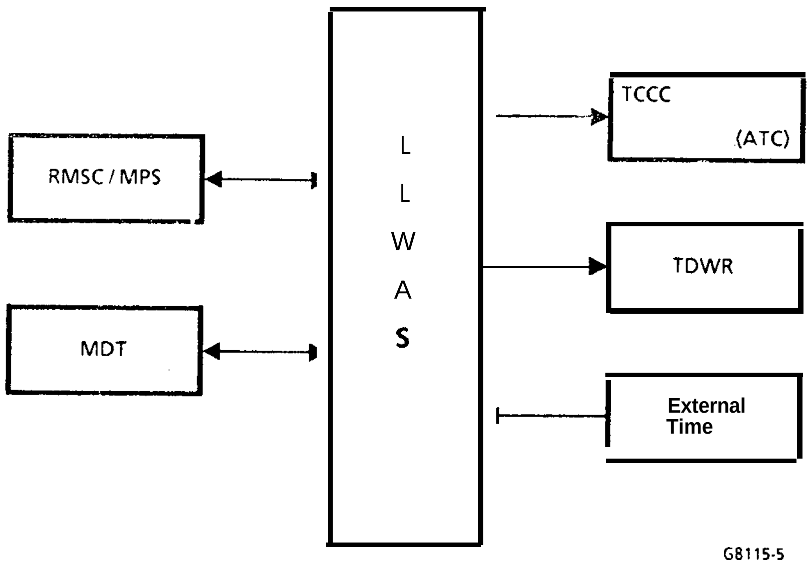

Figure 4 LLWAS External Interfaces

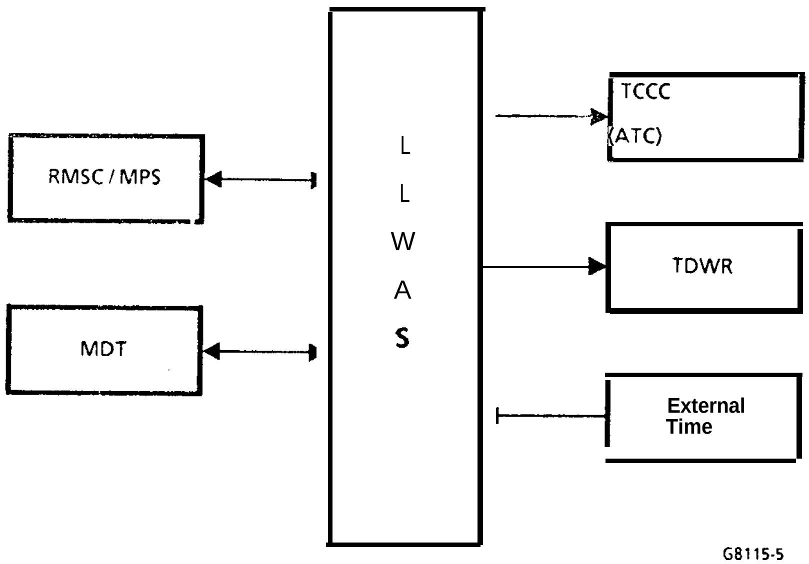

Figure 4 LLWAS External Interfaces

MIL-STD-785 Task 203. Predictions shall be based upon continuous operation using the following environment:

1.) The Remote Station (As defined in paragraph 3.2.1.1.1.1a) shall use Ground Fixed.

2.) The Master Station (As defined in paragraph 3.2.1.1.1d) shall use Ground Benign.

3.2.5.2 Maintainability. Maintainability is the ability of a LLWAS to be retained in or restored to operational conditions when maintenance is performed by technicians having specified skill levels, using prescribed procedures and resources, at each level of maintenance and repair. The LLWAS shall meet an inherent Mean Time to Repair (MTTR) using the definition for MTBF in section 6.2 of 30 minutes.

The Contractor shall conduct a maintainability program which will ensure that the maintainability requirements are met.

a.) The Contractor shall develop a LLWAS maintainability model in accordance with MIL-STD-470 Task 201. The model will be based on equipment configurations specified in paragraph 3.1.3.

b.) The Contractor shall use the LLWAS maintainability model to allocate system-level maintainability requirements to at least the configuration item level, in accordance with MIL-STD-470 Task 202.

c.) The Contractor shall use the LLWAS maintainability model to predict system on-site maintainability in accordance with MIL-STD-470 Task 203.

Equipment utilized in the LLWAS shall be designed to expedite restoration of a system function interrupted by a failure through removal of a readily replaceable modular element containing the faulty element. This replaceable modular element is designated as the Line Replacement Unit (LRU). The definition of an LRU shall be in accordance with FAA-G-1375. Maintenance functions and features shall be integrated in a modular manner to minimize the time required for fault detection, fault isolation, testing, repair and service restoration by making maximum use of current automation techniques and centralized maintenance control.

The Fault Detection and Fault Isolation goal shall be to detect all faults and subsequently the isolation of those faults. The fault isolation shall be to the extent necessary to effect a replacement of the correct LRU with an accuracy of 95 percent and the remaining 5 percent to 3 or less possible candidate LRU's.

The Mean Bench Repair Time (MBRT) using the definition for MBRT for each repairable LRU shall not exceed two hours.

The requirements of this paragraph shall include the communications link.

3.2.5.3 Additional Quality Factors. None.

3.2.6 Environmental Conditions.

3.2.6.1 Sensor Environmental Requirements. The following subsections apply to both the sensor and the Remote Unit housing.

3.2.6.1.1 Water Penetration. There shall be no water condensation, moisture penetration, or absorption. The LLWAS sensor and Remote Station housing shall meet the requirements specified herein and in FAA-G-2100.

3.2.6.1.2 Lightning Protection. LLWAS shall be protected from lightning strikes and transients from nearby strikes in accordance with FAA-STD-019 and FAA-STD-020.

3.2.6.1.3 Icing. The sensor shall conform to the icing requirements of MIL-STD-810 method 521.0.

3.2.6.1.4 Rain. The sensor shall operate under blowing rain conditions and shall be capable of withstanding without damage rain tests in accordance with method 506.2 procedure 1 of MIL-STD-810.

3.2.6.2 Controlled Environment. The LLWAS system equipment located in a controlled environment (Master Station and Displays) shall meet all its functional and performance requirements under the environmental conditions specified in FAA-G-2100, Environment II.

3.2.6.3 Uncontrolled Environment. The LLWAS system equipment located in uncontrolled environment (Remote Stations and Sensors) shall meet all its functional and performance requirement under the environmental conditions specified in FAA-G-2100, Environment III.

3.2.7 Transportability. Material Handling Equipment (MHE) and other resources for the loading, blocking, and bracing of items to be shipped on carrier's equipment as well as on-site loading and transportation of personnel and material shall be provided with the LLWAS system.

3.2.8 Flexibility and Expansion.

3.2.8.1 Processing Power Expansion. The LLWAS processing capacity, memory and data storage shall be expandable by field modification to support up to 6 sensors more than the currently specified number of sensors (22). The expanded system shall meet the requirements of paragraphs in 3.2.1.1.1.a and 3.2.1.1.1.b. The expanded system shall meet the reserve capacity requirements of paragraph 3.3.11.

3.2.9 Portability. Not applicable.

3.3 Design and Construction. The LLWAS equipment shall be designed and constructed in accordance with FAA-G-2100.

3.3.1 Materials.

3.3.1.1 Modular Construction. The LLWAS shall be modular to the extent that failed components are easily replaceable modules with the modularization as defined in MIL-STD-280.

3.3.1.2 Accessibility. Accessibility to racks and LRUs shall be in accordance with FAA-G-2100.

3.3.1.3 Useful Life. LLWAS shall have a useful life of 20 years.

3.3.1.4 Electrical Power Requirements.

3.3.1.4.1 Remote Station Electrical Power Requirements. The Remote Station components shall operate on commercial power services. The power requirements for the Remote Station are:

a.) 150 watts for the Remote Station Electronics.

b.) 1000 watts for the Remote Station Heaters.

3.3.1.4.2 Master Station Electrical Power Requirements. The Master Station components shall operate on FAA-supplied electrical power services available within the host facility. Maximum power shall be 1400 watts for the Master Station.

3.3.1.5 Master Station Power loss of 2 minute or less. The Master Station shall continue full operation when power is lost for 2 minutes or less.

3.3.1.6 Remote Station Power Loss of 48 Hours or Less. The Remote Station shall continue full operation when commercial power is removed for 48 hours or less. This does not include power for heaters.

3.3.1.7 Dissimilar Materials. The materials used for Remote Stations shall be in accordance with MIL-STD-108. The enclosures shall neither degrade or cause deterioration to other parts and subassemblies.

3.3.2 Electromagnetic Radiation. The LLWAS equipment shall meet conducted and radiated emissions requirements of FCC Rules and Regulations, Part 15, subpart J, and of MIL-STD-461, Parts 1 and 7, as applicable to LLWAS when tested to MIL-STD-462.

3.3.3 Nameplates and Product Marking. Nameplates and component marking shall be in accordance with FAA-G-2100.

3.3.4 Workmanship. Workmanship shall be in accordance with FAA-G-2100.

3.3.5 Interchangeability. All LLWAS equipment shall be constructed with assemblies, subassemblies, and replaceable parts being physically and functionally interchangeable without changes or modifications to items or equipment. All equipment shall be designed in accordance with FAA-G-2100.

3.3.6 Safety. LLWAS shall be designed in accordance with FAA Order 3900.19, OSHA Safety and Health Standards (29 CFR 1910), and FAA-G-2100. The design shall be such that its safety features provide for the protection of personnel during the installation, operations, maintenance or repair of any system components.

3.3.7 Human Engineering. The human engineering aspects of the LLWAS equipment design shall comply with MIL-STD-1472 where applicable. All connectors and physical interfaces shall be clearly and legibly labeled. All external switches shall be protected against accidental or inadvertent contact.

3.3.8 Nuclear Control. Not applicable.

3.3.9 System Security. There are no physical security devices required for LLWAS beyond normal Air Traffic Control Tower access.

3.3.10 Government Furnished Equipment (GFE) and Information (GFI) Usage.

3.3.10.1 Site Preparation by Government. The pole mounts for the remote units will be GFE.

3.3.10.2 Geometric Configuration File. The Geometric Configuration File described in Appendix C will be supplied (GFI) for all airport configurations using the Network Expansion LLWAS configuration.

3.3.10.3 Weather Scenarios - Test Cases. All weather scenario input files will contain sufficient data to satisfy those functional and performance requirements allocated to the test.

3.3.11 Computer Resource Reserve Capacity. The Computer Resource Reserve Capacity requirements shall support the following system quantities:

a. 22 Remote Station Sensors

b. 9 Type 1 displays

c. 8 Type 2 displays

d. All interfaces specified in paragraph 3.2.3

3.3.11.1 Memory Capacity. The LLWAS system shall contain a reserve memory capacity of 50%.

3.3.11.2 Central Processing Unit (CPU) Loading. CPU loading shall not exceed a capacity of 50% when averaged over any one second period.

3.3.11.3 Secondary Storage. Secondary storage (both removable and non-removable disk Storage) in the LLWAS system shall contain an excess capacity of 50%.

3.3.12 Electrostatic Discharge. LLWAS equipment shall meet the Electrostatic Discharge Control requirements of DOD-STD-1686.

3.4 Documentation. Documentation shall be developed in accordance with the Statement of Work, DOD-STD-2167 and FAA-D-2494. Data generated during the development of LLWAS shall be documented in drawings, technical manual changes, course materials, and parts lists. Engineering drawing shall be prepared in accordance with DOD-D-1000 and DOD-STD-100. Course materials shall be prepared in accordance with FAA-STD-028. Parts lists in hard copy used for provisioning shall be formatted in accordance with FAA-G-1375 for spare parts-peculiar and FAA-G-1210 for all other lists. Parts lists for provisioning developed from LSA shall be formatted in accordance with MIL-STD-1388-2 and documented in an automated media compatible with an FAA LSA automated database.

3.5 Logistics.

3.5.1 Maintenance Concept. A two-level maintenance concept shall be employed for the LLWAS. These two levels are: (1) site (organizational) and (2) depot. The locations at which the respective maintenance tasks shall be performed are: (1) the

Airport and (2) the FAA Depot or Original Equipment Manufacturer. Maintenance shall be in accordance with FAA Order 6000.30A.

a.) Site-Level Maintenance - maintenance shall be performed at this level on systems, and support equipment in direct support of Air Traffic Control operations. It shall include system maintenance monitoring by RMS, system fault isolation, and correction of system failures through the removal and replacement of LRUs, but shall not include disposition, repair service calibration, and verification of the removed LRUs.

b.) Depot-level maintenance - Support facilities shall be installed at the FAA Depot in Oklahoma City.

3.5.2 Minimum Maintenance. The LLWAS System shall be designed so that all periodic and corrective maintenance shall be accomplished with site visits occurring no more frequently than four times per year.

3.5.3 Support Facilities.

3.5.3.1 Depot Hardware Support. All equipment documentation, and training necessary for the fault isolation, repair, and return of LRUs to an operational state shall be provided.

3.5.3.2 Program Support Facility (PSF). The LLWAS PSF shall be located within the National Airway Engineering Field Support Sector. The PSF shall include all of the equipment, supporting software and firmware, and documentation required for the development, maintenance, testing, analysis and debugging of all LLWAS programs.

3.5.3.3 Hardware Modification Support. All equipment documentation, and training necessary for the development of hardware modifications.

3.5.4 Supply. Spare parts-peculiar for LLWAS shall be identified and acquired in accordance with FAA Specification FAA-G-1375. Repairable LRUs shall be identified and spares requirements quantified from logistic support analysis (LSA) in accordance with MIL-STD-1388-1. Logistics Support Analysis Record (LSAR) data shalll be provided in accordance with MIL-STD-1388-2. Provisioning lists shall be developed from data generated by LSA and formatted in accordance with MIL-STD-1561. Determination of spare LRUs to be stocked onsite shall be based on calculated or experience failure rates of the LRUs.

3.6 Training. FAA site personnel shall be trained to operate the LLWAS using the technical manual and to maintain it in accordance with the maintenance procedures of the technical manual. FAA Depot engineers shall be trained in the repair and modification of LRUs.

3.7 Characteristics of Subordinate Elements. This specification does not identify any subordinate elements. This determination is left to the Contractor for full flexibility.

3.8 Precedence. Prior to proposal submission, the Government shall be notified of conflicting, or apparently conflicting requirements contained within this specification or between this specification and other referenced documents. The Government will review all conflicts reported by the contractor, and will determine which documents take precedence.

3.9 Qualification. This section describes the overall philosophy of LLWAS qualification, test location, test responsibilities, qualification methods and test levels.

3.9.1 Philosophy of Testing. The LLWAS shall be evaluated in a hierarchy of tests that demonstrate, verify, and validate:

a.) Compliance with all functional and performance requirements stated in this specification.

b.) Operability of the LLWAS under the full range of possible simultaneous processing requirements.

c.) User interface with the LLWAS.

d.) Regression tests - When modifying or making additions to the system (hardware or software), tests shall be conducted to insure that areas not changed have not been degraded.

A defined set of LLWAS requirements are extracted from FAA-E-2697A, logically broken down into Computer Software Configuration Items (CSCI), Computer Software Components (CSC), and Computer Software Units (CSU). The contractor shall design the test program to perform integration tests to progress from the CSU level, then to the CSC level, next to the CSCI level, and up to the FAA system integration level testing with the actual FAA interfaces.

Hardware Configuration Item (HWCI) compliance shall be established through those test levels that combine both off-the-shelf and existing hardware with developing software.

3.9.2 Location of Tests. Both informal and formal tests of software units, Computer Software Component (CSC), Computer Software Configuration Item (CSCI) and HWCI shall be performed at the Contractor facility. The System Integration Test shall be performed at the FAATC or at a key site. Site Acceptance Test shall be performed at the key site and all operational sites thereafter.

3.9.3 Qualification Methods.

3.9.3.1 Test. Test is a method of verifying performance requirements of subsystem, system or configuration items by quantitative measurements of controlled functional or environmental stimuli. These dynamic measurements are made using standardized laboratory equipment, procedures or other services, then analyzed to determine their compliance.

3.9.3.2 Demonstration. Demonstration is a method of verifying subsystem, system or configuration item requirements by observing their functional response to dynamic exercising. This qualitative evaluation is made using criteria from technical procedures, excluding measurements. Acceptance is based on pass or fail results.

3.9.3.3 Analysis. Analysis is a method of verifying requirements for hardware or software design by comparing it mathematically (modeling) or otherwise with known scientific and technical principles, procedures or practices. Results of the comparison are used to estimate the capability of the design to meet system and mission requirements. Justification for analysis is inaccessibility for testing.

3.9.3.4 Inspection. Inspection is a method of verifying acceptability of hardware, software or technical documentation by determining it's compliance to requirements by visual examination of it's condition or content. The criteria for examination is obtained from standards, schematics or affidavits consisting of static-state measurements, inventories or conformance features. The success criteria is pass or fail.

3.9.4 Test Levels. There are three basic levels of test and all requirements identified in this specification shall be verified at one or more of these levels.

3.9.4.1 Subsystem. This level of verification is usually accomplished at the contractor's facility where functional or performance or both requirements for a subsystem or configuration item are evaluated. Use of simulators for preliminary evaluation of subsystem operability or interoperability, in preparation for complete integrated testing, is common.

3.9.4.2 Integration. This level of verification is usually conducted at the FAATC or a key site. It will determine if the subsystem or configuration item to be deployed for site installation will operate in accordance with NAS system level functional, performance and pertinent operational requirements when it is configured or integrated in it's operational environment.

3.9.4.3 Site. This level of verification is conducted at the designated site(s). The Installation and Checkout process as well as all other commissioning activities of a system including shakedown, JAI, etc. will provide for the final acceptance of subsystem or configuration item. System level requirements addressing the entire NAS or potentially affected by local site conditions are included.

3.9.4.4 Verification Categories. LLWAS testing is structured into the three major test categories Development Test and Evaluation (DT&E), Operational Test and Evaluation (OT&E), and Production Acceptance Test and Evaluation (PAT&E). DT&E is that testing performed for design assistance, technical risk assessment, and specification performance verification. OT&E is performed to determine operational effectiveness and operational suitability. Operational effectiveness is the degree to which a system accomplishes its mission in the context of organization, policy, and environment when it operates as planned. Operational suitability is the degree to which a system can be placed satisfactorily in field use, with consideration being given to availability, compatibility, transportability, interoperability, reliability, maintainability, safety, human factors, manpower supportability, logistic supportability, and training requirements. PAT&E is testing performed to ascertain whether a production system has been fabricated properly and as such satisfies the specification to which it was built.

3.9.4.4.1 DT&E. DT&E is that T&E conducted primarily to assist the engineering design and development process by determining incrementally the degree to which functional engineering specifications are attained. DT&E includes T&E of systems, subsystems, units, hardware, software, full-scale engineering models and prototypes. DT&E includes functional T&E of unit, subsystem and system integration; testing functional integration of hardware with software and the operational program; and testing functional compatibility and integration with operational systems on sites and with the NAS.

3.9.4.4.2 OT&E. OT&E is conducted to:

a.) Estimate and determine a system's operational effectiveness and operational suitability to be part of the NAS.

b.) Identify needed modifications.

c.) Provide information on policy, organization, personnel and other operational requirements

Programs should be structured so that OT&E begins early and makes maximum use of DT&E testing.

OT&E is conducted from a different perspective than DT&E and PAT&E, and therefore requires the participation of the operations and maintenance organizations to validate that operational requirements are met. OT&E requires operational realism in the test environment, in test objectives, in system boundaries and interfaces, in system operation and in test conduct. OT&E focuses on resolution of critical operational issues and is conducted in phases, each keyed to an appropriate decision point.

3.9.4.4.3 PAT&E. PAT&E is that T&E of production items to verify that the procured items fulfill the requirements and specifications of the procuring contract or agreement. Note: The differences between the scope of DT&E and PAT&E depend on how much testing was done and on how much the test articles have changed.

3.9.5 Formal Tests. The purpose of formal testing is to perform a test of the complete LLWAS system after shipment to a Government facility (FAATC, key site, operational site). Test Readiness shall be established at the Test Readiness Review prior to the test. This test can be a rerun of a previous test and shall have Government witnesses.

3.9.5.1 Detection Performance Tests. As part of formal testing, the integrated LLWAS system (hardware, software) shall follow a test scenario that includes a variety of weather events. These scenario test files will be Government supplied as described in 3.3.10.3.

3.9.6 Formal Test Constraints. The formal test shall use Government provided input files for the simulation of sensor input data. The system parameter files that are provided by the Government shall be based on acceptable configurations that meet the requirements of the LLWAS Siting Manual.

3.9.7 External Equipment Environmental Tests. The external equipment shall be tested to meet all functional and performance requirements, under ambient conditions specified in FAA-G-2100 for Environment III.

3.10 Standard Sample. Not Applicable.

3.11 Production Sample, Periodic Production Sample, Pilot, or Pilot Lot. Not applicable.

3.12 Software Development.

3.12.1 Programming Languages. All software developed for the LLWAS System shall be written in a single higher order programming language (HOL) except for those cases where it is shown that processing efficiency requirements dictate the use of a lower order language. No lower order language shall be used without advance Government approval in each instance.

3.12.1.1 Unit Attributes. Structured programming techniques shall be employed. All units shall be implemented with one entry and one exit, with the exception for error conditions. All program units will have the following additional attributes:

a.) A program unit shall contain the code required to implement a single, well-define function and shall consist of not more than 100 executable, high-order language statements.

b.) All source codes shall be indented to clearly denote logical levels of constructs for ease of visual inspection.

c.) All segments shall have sufficient annotation, i.e., comments, to explain inputs, outputs, branches, and other items not obvious in code itself. Explanatory notes shall be uniformly indented.

d.) Statements shall be grouped and arranged in a meaningful order in the code, e.g., columnar rather than a horizontal string.

e.) Data declarations shall be grouped and arranged in a meaningful order in the code, e.g., columnar rather than a horizontal string.

f.) Data names and procedure labels shall be meaningful in that labels shall be suggestive of their function.

g.) Each line of source code shall contain one statement only.

h.) Formats for error and diagnostic messages shall be standardized and shall require no additional interpretation such as table lookups.

i.) Loop indexes shall not be altered during loop execution.

j.) Unnecessary assignment of a constant value to a variable (especially within a loop) shall not be made.

k.) Units shall not share temporary storage locations of variables.

l.) Each unit shall be uniquely identified.

m.) Except for error exits, each unit shall have a single entry point and single exit point.

n.) Complicated expressions, such as compounded negative Boolean expressions and nesting beyond three levels, shall not be used.

3.12.2 Operability. The software shall detect, store, and notify that software errors have occurred. Location in the software (unit identification) and time of occurrence shall be included with the stored information. Recovery from abnormal conditions shall be provided.

j.) Unnecessary assignment of a constant value to a variable (especially within a loop) shall not be made.

k.) Units shall not share temporary storage locations of variables.

l.) Each unit shall be uniquely identified.

m.) Except for error exits, each unit shall have a single entry point and single exit point.

n.) Complicated expressions, such as compounded negative Boolean expressions and nesting beyond three levels, shall not be used.

3.12.2 Operability. The software shall detect, store, and notify that software errors have occurred. Location in the software (unit identification) and time of occurrence shall be included with the stored information. Recovery from abnormal conditions shall be provided.

5.0 PREPARATION FOR DELIVERY.

5.1 Packaging Requirements for System Equipment. System equipment being shipped directly to each designated site location for immediate installation shall be prepared for delivery in accordance with ASTMD D 3951-82. However, in the event the system equipment is sent to the FAA Depot for storage, the equipment shall be individually preserved or packaged to Level A, and packed to Level B in accordance with MIL-E-17555.

5.1.1 Packaging Requirements for Spares.

5.1.1.1 Site Stocks and Workcenter Stocks. Site stocks and workcenter stocks (spare parts) shipped directly to sites shall be packaged and marked in accordance with ASTM D 3951-82.

If it is decided that these stocks (spares) will be procured for depot storage, they shall be packaged as specified for depot stocks (spares).

5.1.1.2 Depot Stocks.

a.) Preservation or Packaging. All depot stocks (spares), except common hardware, shall be individually preserved or packaged in accordance with MIL-E-17555, Level A.

Common hardware items shall be packaged in multiple unit pack quantities as normally supplied through retail trade channels or in standard commercial unit pack quantities compatible with unit of issue (i.e., unit of issues is gross then the unit package is gross). Appendix F of MIL-STD-794 shall be used as a guide in determining the standard quantity per unit container. (Bulk quantities not acceptable).

When applicable, parts comprising a single set, kit, or assembly, shall be individually protected and packed together as a single unit in one container and identified. When two or more containers are used, they shall be marked 1 of 2, 2 of 2, etc. in accordance with MIL-STD-129. When a kit is composed of one or more containers, the same items shall always be packed in the same numbered container.

Packaging materials (preservatives, wraps, cushioning, etc.) shall be utilized that conform to any and all types listed by document number in MIL-STD-794.

b.) Packing. Exterior shipping containers shall be used that meet the requirements of MIL-E-17555 Level C. The number of items packed in a container is the option of the Contractor but shall contain identical stock numbered items.

Containers that are designed as shipping containers for single line items are to be adequately cushioned, blocked, braced and anchored to prevent movement and possible damage to the item. Additionally, these containers are to be Level B unless otherwise specified, in which case overpacking is not required for items shipped as single units.

When shipping limited quantities of items of more than one property class of stock number, the items shall be packed in the same exterior shipping container. All identical stock numbered items shall be segregated and packed, then placed in an exterior shipping container for shipment. This shipping container must indicate "Multiple Line Items" or "Mixed Stock" and shall be marked "See the attached packing list for contents and quantity."

All items identified as Electrostatic Discharge Sensitive (ESD) shall be preserved, packaged, packed and marked in accordance with all applicable documents referenced in MIL-E-17555.

5.1.2 Marking.

All containers shall be marked in accordance with MIL-STD-129. In addition, each package shall be marked with its shipping address and have the following information included in the shipping label:

a.) Contract number and line item number

b.) Manufacturer's name and address

c.) Manufacturer's part number

d.) Name of item and FAA type designation

e.) Quantity

f.) National Stock Number (NSN)

g.) Gross weight of container

h.) Serial Numbers

i.) Warranty expiration date

Each package, shipping container, replaceable item, and its container shall be marked and bar coded in accordance with MIL-STD-1189.

5.1.3 Packing Requirements for Software. The LLWAS software shall be delivered on target system compatible media in an electrostatic protected package. The package shall be protected from wind, rain, and inadvertent radiation.

6.0 NOTES.

6.1 Intended Use.

6.1.1 Mission. The Network Expansion LLWAS will be installed at major airports with Air Traffic Control Towers to detect the presence of hazardous wind shear. The LLWAS processes information provided from sensors using special algorithms that will identify the degree of severity and the location with respect to the operational runway. In addition to windshear alerts the centerfield winds and threshold winds are displayed.

6.1.2 Threat. Not applicable.

6.1.3 Acronyms.

ASCII	American Standard Code for Information Exchange
ATC	Air Traffic Control
ATCS	Air Traffic Control Specialist
CF	Centerfield
CFR	Code of Federal Regulations
CI	Configuration Item
CSC	Computer Software Component
CSCI	Computer Software Configuration Item
CTS	Coded Time Source
DOD	Department Of Defense
DT&E	Development Test and Evaluation
EIA	Electronics Industries Association
ESD	Electrostatic Discharge
FAA	Federal Aviation Administration
FAATC	Federal Aviation Administration Technical Center
FAR	False Alarm Ratio
FAT	Factory Acceptance Test

FCC	Federal Communications Commission
GCF	Geometric Configuration File
GFE	Government Furnished Equipment
GFI	Government Furnished Information
HOL	Higher Order Language
HWCI	Hardware Configuration Item
LLWAS	Low Level Wind Shear Alert System
LRU	Line Replaceable Unit
LU	Logical Unit
MBA	Microburst Alert
MCC	Maintenance Control Center
MDT	Maintenance Data Terminal
MPS	Maintenance Processor Subsystem
MTBF	Mean Time Between Failures
NAS	National Airspace System
NCAR	National Center for Atmospheric Research
NFPA	National Fire Protection Association
NMN	Network Mean
OSHA	Occupational Safety and Health Administration
OT&E	Operational Test and Evaluation
POD	Probability of Detection
RMSC	Remote Monitoring Subsystem Concentrator
ROG	Runway Oriented Gain
ROL	Runway Oriented Loss
SAT	Site Acceptance Test
SIT	System Integration Test

FCC	Federal Communications Commission
GCF	Geometric Configuration File
GFE	Government Furnished Equipment
GFI	Government Furnished Information
HOL	Higher Order Language
HWCI	Hardware Configuration Item
LLWAS	Low Level Wind Shear Alert System
LRU	Line Replaceable Unit
LU	Logical Unit
MBA	Microburst Alert
MCC	Maintenance Control Center
MDT	Maintenance Data Terminal
MPS	Maintenance Processor Subsystem
MTBF	Mean Time Between Failures
NAS	National Airspace System
NCAR	National Center for Atmospheric Research
NFPA	National Fire Protection Association
NMN	Network Mean
OSHA	Occupational Safety and Health Administration
OT&E	Operational Test and Evaluation
POD	Probability of Detection
RMSC	Remote Monitoring Subsystem Concentrator
ROG	Runway Oriented Gain
ROL	Runway Oriented Loss
SAT	Site Acceptance Test
SIT	System Integration Test

Remote Station - Remote Station shall be the group of equipment located at one of the configured sites on the airport from which all wind data is measured and retrieved from.

Scan cycle - A scan cycle or poll shall be the interrogation and response (if available) process repeated once per station for all configured remote stations.

Operational Runway - An operational runway is a runway designation with the following characteristics: direction (in degrees with last zero dropped i. e. 350 becomes 35), position (Right, Left or Center), and mode of operation (arrival or departure).

MBRT - MBRT is the total **LRU** bench repair time to include set up and fault isolation time, and verification time divided by the total number of failures that require corrective maintenance.

MTTR - A basic measure of maintainability: The total time required to diagnose the problem, replace the **LRU** and subsequently check out the system divided by the number of times such maintenance actions were required.

MTBF - A basic measure of reliability for repairable items: The mean number of life units during which all parts of the item perform within their specified limits, during a particular measurement interval under stated conditions.

APPENDIX A

NCAR ALGORITHM REPORT

APPENDIX A

NCAR ALGORITHM REPORT

FAA-E-2697A
March 6, 1989

SPECIFICATION: ENHANCED LLWAS ALGORITHMS

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June 28, 1988

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I. INTRODUCTION

The enhanced LLWAS will reliably detect hazardous wind shear and identify microburst wind shear in the airport envirorment. The final product is a warning message for each impacted runway.

Each physical runway has two directions of use and two modes of operation – arrival and departure – for each direction. Therefore, each physical runway corresponds to four operational runways. A separate warning message is issued for each operational runway.

The LLWAS network consists of anemometer stations. A *network element* is a station, an edge determined by a pair of stations, or a triangle determined by a triple of stations. A *runway* alarm *association table* indicates which network elements are associated with each operational runway. The government will furnish the list of network elements , the runway alarm association table, and other associated geometric information for each airport. All of of this information will be contained in the geometric *configuration file.*

The procedure used is first to determine if there is a wind shear condition at the airport and then to determine whether it is posing a hazard on any given operational runway. There is a wind shear at the airport if some network element is in alarm status. Algorithms to determine this condition are described in Sections II through *VII*

The wind shear is a potential hazard for an operational runway if it occurs at a network element associated with that runway. The flow chart in Figure 1 provides the decision tree for determining:

i. Is there a hazard on the runway?

ii. The type of hazard (wind shear or microburst).

iii. The location of the expected first encounter with the hazard.

iv. The estimated headwind loss or gain associated with the hazard.

To eliminate alerts for short-lived events (false alarms), an alert message is issued for the runway only when the hazard condition on the runway persists for a specified number of consecutive polls. The algorithms for the computations indicated in Figure 1 are described in Sections *VIII* through *XI*.

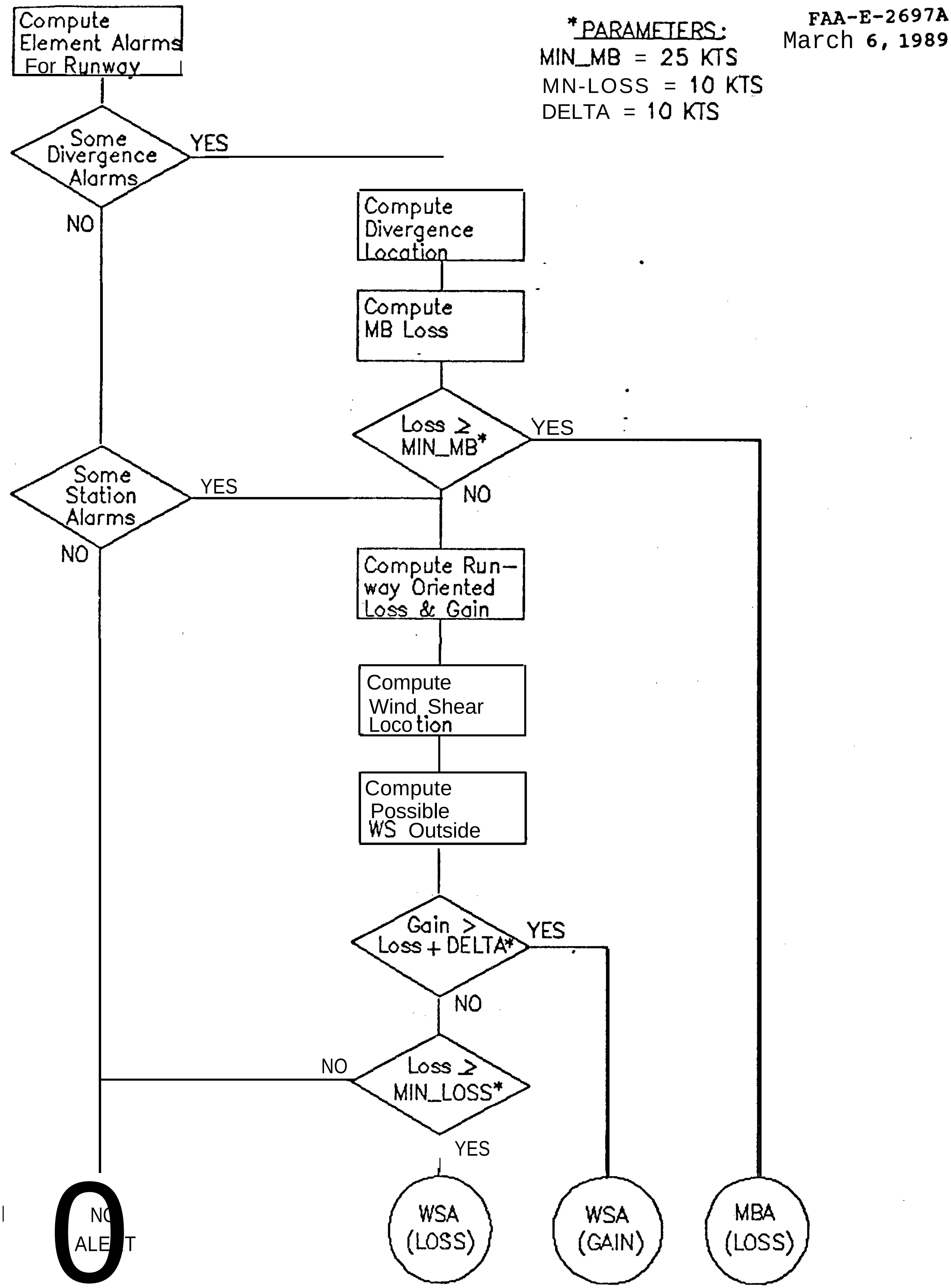

FIGURE 1. RUNWAY ALERT DECISION LOGIC

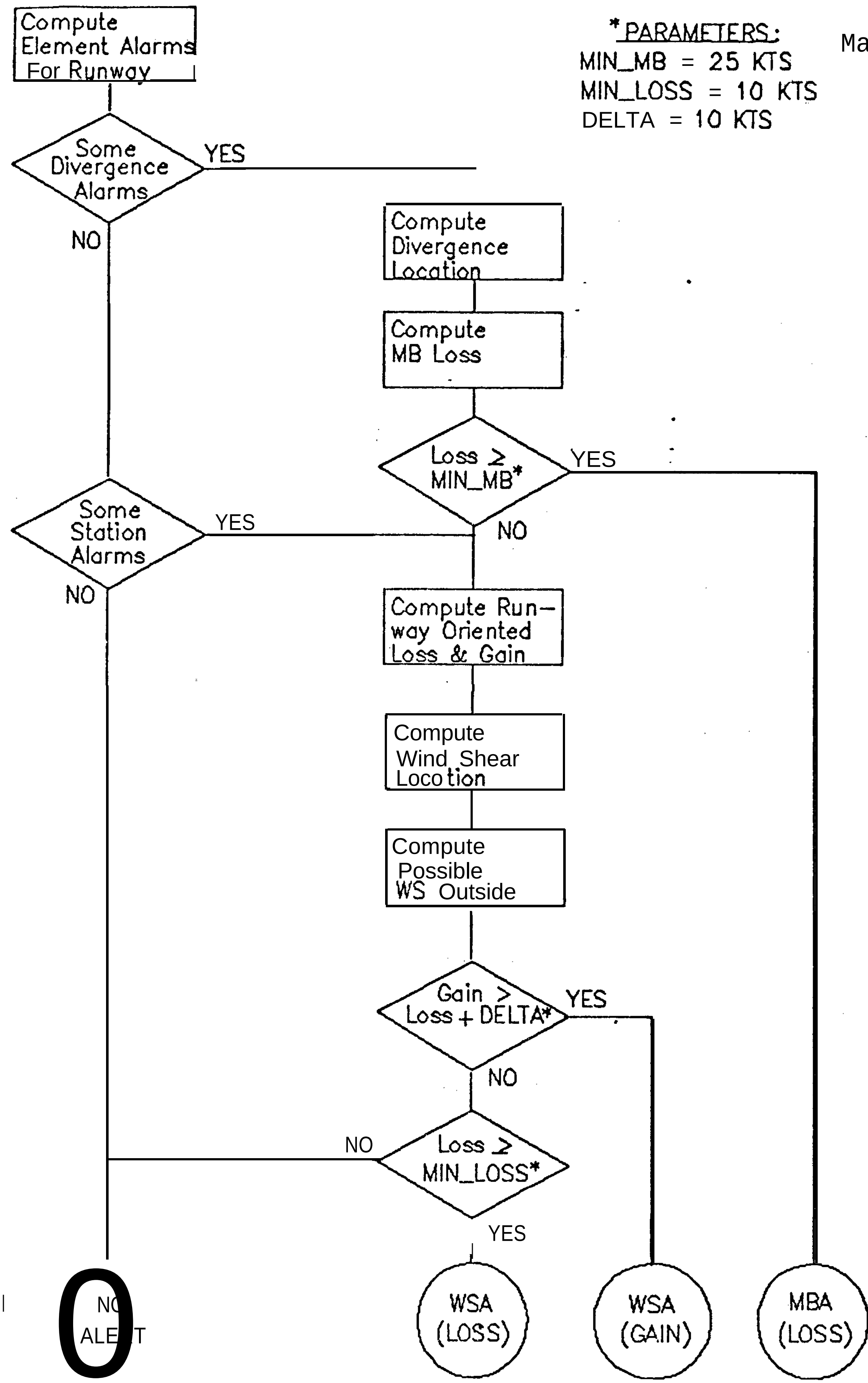

FIGURE 1. RUNWAY ALERT DECISION LOGIC

2) Input

A time series of data $X(t)$

3) Initialization

$Y(1) = X(1)$

4) Compute For $t > 1$

$$Y(t) = \alpha Y(t-1) + (1-\alpha)X(t)$$

5) Output

The time series of smoothed data $Y(t)$.

II.2 DOUBLE POLE FILTER

The single pole recursive filter does a good job smoothing noisy data. However, it may delay the response. A double pole recursive filter allows for both adequate noise suppression and a more timely response.

A. THE METHOD

The double pole infinite impulse response digital filter, in vector notation, is defined by the relationship (at time t):

$$\vec{M}_{temp} = A\vec{M}_z + \vec{b}z(t)$$

$$Z_2(t) = \vec{c}\,' \cdot \vec{M}_z + dz(t),$$

$$\vec{M}_z = \vec{M}_{temp}$$

where A is a 2 by 2 matrix, $\vec{b}$ and $\vec{c}\,'$ are 2 element vectors, and d is a scalar. The vector $\vec{M}_z$ is the internal memory (state) vector associated with the input scalar z. $\vec{M}_{temp}$ is a temporary vector and the scalar Z_2 is the filtered output.

B. ALGORITHM SPECIFICATION

1) Parameters

The nine (unitless) parameters in the four arrays $A, \vec{b}, \vec{c}\,'$, and d are real valued filter constants.

$$
\begin{array}{llll}
a(1,1) = 0.00 & a(1,2) = 1.00 \\
a(2,1) = -0.219654 & a(2,2) = 0.5193 \\
b(1) = 0.0 & b(2) = 1.0 \\
c(1) = 0.13663 & c(2) = 0.4411 \\
d = 0.1751 &
\end{array}
$$

2) Input

$u(t,i)$ and $v(t,i)$ the wind field components at time t, from each of the stations i = $1,\ldots,n$.

3) **Initialization** $t = 1$

$$\vec{M}_u(i) = \frac{u(1,i)}{(1.0-a(2,1)-a(2,2)}, \quad \vec{M}_v(i) = \frac{v(1,i)}{(1.0-a(2,1)-a(2,2)}$$

for i = $1,\ldots,n$.

4) compute for $t \geq 1$

$$M_{temp}(1) = a(1,1) * M_u(i)(1) + a(1,2) * M_u(i)(2) + b(1) * u(t,i)$$

$$M_{temp}(2) = a(2,1) * M_u(i)(1) + a(2,2) * M_u(i)(2) + b(2) * u(t,i)$$

$$U_2(t,i) = c(1) * M,(i)(l) + c(2) * M_u(i)(2) + d * u(t,i)$$

$$M_u(i)(1) = M_{temp}(1)$$

$$M_u(i)(2) = M_{temp}(2)$$

for stations i, i $= 1,\ldots,n$.

Similarly for the v components,

$$M_{temp}(1) = a(1,1) * M_v(i)(1) + a(1,2) * M_v(i)(2) + b(1) * v(t,i)$$

$$M_{temp}(2) = a(2,1) * M_v(i)(1) + a(2,2) * M_v(i)(2) + b(2) * v(t,i)$$

$$V_2(t,i) = c(1) * M_(i)(1) + c(2) * M_v(i)(2) + d * v(t,i)$$

$$M_v(i)(1) = M_{temp}(1)$$

$$M_v(i)(2) = M_{temp}(2)$$

for stations i, i $= 1,\ldots,n$.

1) Parameters

The nine (unitless) parameters in the four arrays $A, \vec{b}, \vec{c}\,'$, and d are real valued filter constants.

$$
\begin{array}{ll}
a(1,1) = 0.00 & a(1,2) = 1.00 \\
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b(1) = 0.0 & b(2) = 1.0 \\
c(1) = 0.13663 & c(2) = 0.4411 \\
d = 0.1751 &
\end{array}
$$

2) Input

$u(t,i)$ and $v(t,i)$ the wind field components at time **t**, from each of the stations $i = 1, \ldots, n$.

3) **Initialization** $t = 1$

$$\vec{M}_u(i) = \frac{u(1,i)}{(1.0-a(2,1)-a(2,2)}, \quad \vec{M}_v(i) = \frac{v(1,i)}{(1.0-a(2,1)-a(2,2)}$$

for i $= 1, \ldots, n.$

4) compute for $t \geq 1$

$$M_{temp}(1) = a(1,1) * M_u(i)(1) + a(1,2) * M_u(i)(2) + b(1) * u(t,i)$$

$$M_{temp}(2) = a(2,1) * M_u(i)(1) + a(2,2) * M_u(i)(2) + b(2) * u(t,i)$$

$$U_2(t,i) = c(1) * M_u(i)(1) + c(2) * M_u(i)(2) + d * u(t,i)$$

$$M_u(i)(1) = M_{temp}(1)$$

$$M_u(i)(2) = M_{temp}(2)$$

for stations i, i $= 1, \ldots, n.$

Similarly for the v components,

$$M_{temp}(1) = a(1,1) * M_v(i)(1) + a(1,2) * M_v(i)(2) + b(1) * v(t,i)$$

$$M_{temp}(2) = a(2,1) * M_v(i)(1) + a(2,2) * M_v(i)(2) + b(2) * v(t,i)$$

$$V_2(t,i) = c(1) * M(i)(1) + c(2) * M_v(i)(2) + d * v(t,i)$$

$$M_v(i)(1) = M_{temp}(1)$$

$$M_v(i)(2) = M_{temp}(2)$$

for stations i, i $= 1, \ldots, n.$

2) Input

n, the number of currently active stations.

$u(t,i)$ and $v(t,i)$ in $(m/s)^2$, the wind field components at time t, from each of the stations $i = 1, \ldots, n$.

$U_2(t,i)$ and $V_2(t,i)$ in $(m/s)^2$, the double pole filtered wind field components at time t, from each of the stations $i = 1, \ldots, n$.

3) Initialization

$$U_\alpha(1,i) = u(1,i), \quad V_\alpha(1,i) = v(1,i)$$

$$\sigma^2_{u\gamma} = \sigma^2_{min}, \quad \sigma^2_{v\gamma} = \sigma^2_{min}$$

4) Compute for $t > 1$ **[MODEL_SINGLE_STAT]**

a) Update the wind field averages with a very slow *single pole filter* **[TS_UPDATE]**

$$U_\alpha(t,i) = \alpha U_\alpha(t-1,i) \text{ t } (1-\alpha)u(t,i)$$

$$V_\alpha(t,i) = \alpha V_\alpha(t-1,i) \text{ t } (1-\alpha)v(t,i)$$

b) Compute the residuals between the two filtered data sets [RESIDUAL]

$$R^2_u(t,i) = (U_\alpha(t,i) - U_2(t,i))^2$$

$$R^2_v(t,i) = (V_\alpha(t,i) - V_2(t,i))^2$$

c) Update the variances at each station (using the residuals) with a single pole filter **[VARIANCE_UPDATE]**

$$\sigma^2_{u\gamma}(t,i) = \gamma\sigma^2_{u\gamma}(t-1,i) + (1-\gamma)R^2_u(t,i)$$

$$\sigma^2_{v\gamma}(t,i) = \gamma\sigma^2_{v\gamma}(t-1,i) + (1-\gamma)R^2_u(t,i)$$

5) Output

$R^2_u(t,i)$, $R^2_v(t,i)$ the Temporal Shear residuals at each station.
$\sigma^2_{u\gamma}(t,i)$, $\sigma^2_{v\gamma}(t,i)$ the Temporal Shear variances.

IV. NETWORK MEAN (NMN)

A. THE METHOD

The network mean computation is stabilized by trimming outliers from the set of station data. An outlier is the data from any station that is rejected by a Chi-squared test:

$$\frac{[u(t,i) - \bar{u}(t-1)]^2}{\sigma_u^2(t-1)} + \frac{[v(t,i) - \bar{v}(t-1)]^2}{\sigma_v^2(t-1)} > \text{Trim Threshold}$$

where ii, $\bar{v}$ are the network mean estimates from the previous 'polling and σ_u^2, σ_v^2 are the respective variance estimates. The next estimates of the network means and variances are computed from the data from the stations that have not been trimmed. These parameters are averaged with the model parameters from previous times by use of the single pole recursive filter.

B. ALGORITHM SPECIFICATION

1) Parameters

β – single pole filter constant; network mean model (β=.8, unitless)

γ– single pole filter constant; network variances (γ=.995, unitless)

Trim-threshold = 10.0 (unitless)

σ^2_{min} = 4.0 $in(m/s)^2$

start-uptime = 30 (in data polls)

2) Input

$u(t,i), v(t,i)$ the. wind field values at time t for each of the stations i = $1, \ldots, n$

$U_2(t,i), V_2(t,i)$ the double pole filtered wind field values at time t for each of the stations i = $1, \ldots, n$

8) Initialization(for t=1, . . . , start_up_time) **[START_UP_NMN]**

a) First estimate of the network mean **[NMN]**

$$\bar{U}(t) = (1/n)\sum_{i=1}^{n} U_2(t,i), \quad \bar{V}(t) = (1/n)\sum_{i=1}^{n} V_2(t,i)$$

b) Trim from the data set the two stations which have the largest vector differences from the network mean, i.e., the 2 values of i that maximize the following: **[TRIM_VD]**

$$||(U_2(t,i), V_2(t,i)) - (\bar{U}(t), \bar{V}(t))||$$

c) Recompute the network mean using the untrimmed (remaining) data set $\{j\}$. **[RE-MODEL_NMN]**

$$\bar{U}_T(t) = (\frac{1}{n-2})\sum_j U_2(t,j), \quad \bar{V}_T(t) = (\frac{1}{n-2})\sum_j V_2(t,j)$$

d) Update the time-series average of the network mean with a single pole filter. **[TS_UPDATE]**

for $t = 1$

$$\bar{U}_{T\beta}(1) = \bar{U}_T(1), \ \bar{V}_{T\beta}(1) = \bar{V}_T(1)$$

for $t > 1$

$$\bar{U}_{T\beta}(t) = \beta\bar{U}_{T\beta}(t-1) + (1-\beta)\bar{U}_T(t)$$

$$\bar{V}_{T\beta}(t) = \beta\bar{V}_{T\beta}(t-1) + (1-\beta)\bar{V}_T(t)$$

e) Compute the residuals of the entire data set from the updated network mean [RESIDUAL)

$$R_u^2(t,i) = (U_2(t,i) - \bar{U}_{T\beta}(t))^2, \quad R_v^2(t,i) = (V_2(t,i) - \bar{V}_{T\beta}(t))^2$$

f) Compute the sample variance of the data using residuals over the untrimmed data set [VARIANCE]

$$\sigma_u^2(t) = (\frac{1}{n-3})\sum_j R_u^2(t,j), \quad \sigma_v^2(t) = (\frac{1}{n-3})\sum_j R_v^2(t,j)$$

g) Update the time-series average of the sample variance with a single pole filter. [VARIANCE-UPDATE)

for $t = 1$

$$\sigma_{u\gamma}^2(1) = \sigma_u^2(1), \quad \sigma_{v\gamma}^2(1) = \sigma_v^2(1)$$

for $t > 1$

$$\sigma_{u\gamma}^2(t) = \gamma\sigma_{u\gamma}^2(t-1) + (1-\gamma)\sigma_u^2(t),$$

$$\sigma_{v\gamma}^2(t) = \gamma\sigma_{v\gamma}^2(t-1) + (1-\gamma)\sigma_v^2(t)$$

8) Initialization(fort=1,. . . , start_up_time) **[START_UP_NMN]**

a) First estimate of the network mean [NMN]

$$\bar{U}(t) = (1/n)\sum_{i=1}^{n} U_2(t,i), \quad \bar{V}(t) = (1/n)\sum_{i=1}^{n} V_2(t,i)$$

b) Trim from the data set the two stations which have the largest vector differences from the network mean, i.e., the 2 values of i that maximize the following: [TRIM_VD]

$$||(U_2(t,i), V_2(t,i)) - (\bar{U}(t), \bar{V}(t))||$$

c) Recompute the network mean using the untrimmed (remaining) data set $\{j\}$. [RE-MODEL_NMN]

$$\bar{U}_T(t) = (\frac{1}{n-2})\sum_j U_2(t,j), \quad \bar{V}_T(t) = (\frac{1}{n-2})\sum_j V_2(t,j)$$

d) Update the time-series average of the network mean with a single pole filter. [TS_UPDATE]

for $t = 1$

$$\bar{U}_{T\beta}(1) = \bar{U}_T(1), \ \bar{V}_{T\beta}(1) = \bar{V}_T(1)$$

for $t > 1$

$$\bar{U}_{T\beta}(t) = \beta\bar{U}_{T\beta}(t-1) + (1-\beta)\bar{U}_T(t)$$

$$\bar{V}_{T\beta}(t) = \beta\bar{V}_{T\beta}(t-1) + (1-\beta)\bar{V}_T(t)$$

e) Compute the residuals of the entire data set from the updated network mean [RESIDUAL]

$$R_u^2(t,i) = (U_2(t,i) - \bar{U}_{T\beta}(t))^2, \quad R_v^2(t,i) = (V_2(t,i) - \bar{V}_{T\beta}(t))^2$$

f) Compute the sample variance of the data using residuals over the untrimmed data set [VARIANCE]

$$\sigma_u^2(t) = (\frac{1}{n-3})\sum_j R_u^2(t,j), \quad \sigma_v^2(t) = (\frac{1}{n-3})\sum_j R_v^2(t,j)$$

g) Update the time-series average of the sample variance with a single pole filter. [VARIANCE-UPDATE]

for $t = 1$

$$\sigma_{u\gamma}^2(1) = \sigma_u^2(1), \quad \sigma_{v\gamma}^2(1) = \sigma_v^2(1)$$

for $t > 1$

$$\sigma_{u\gamma}^2(t) = \gamma\sigma_{u\gamma}^2(t-1) + (1-\gamma)\sigma_u^2(t),$$

$$\sigma_{v\gamma}^2(t) = \gamma\sigma_{v\gamma}^2(t-1) + (1-\gamma)\sigma_v^2(t)$$

g) Update the time-series average of the sample variance with a single pole filter. [VARIANCE UPDATE]

$$\sigma^2_{u\gamma}(t) = \gamma\sigma^2_{u\gamma}(t-1) + (1-\gamma)\sigma^2_u(t)$$
$$\sigma^2_{v\gamma}(t) = \gamma\sigma^2_{v\gamma}(t-1) + (1-\gamma)\sigma^2_v(t)$$

h) Recompute the residuals of the entire (raw) data set from the updated network mean. [RESIDUAL]

$$R^2_u(t,i) = [u(t,i) - \bar{U}_{T\beta}(t)]^2, \quad R^2_v(t,i) = [v(t,i) - \bar{V}_{T\beta}(t)]^2$$

5. *Output*

$R^2_u(t,i)$, $R^2_v(t,i)$ *for* $i = 1, \ldots, n$, the Network Mean residuals for each station.
$\sigma^2_{u\gamma}(t)$, $\sigma^2_{v\gamma}(t)$, the filtered Network Mean variances.

V. TRIANGLE AND EDGE DIVERGENCE (TED)

The physical characteristic of a microburst that makes it an aviation hazard is the presence of the low level divergent wind shear. When the event is inside of the LLWAS network and it is large enough to have a significant impact on more than one station, then it frequently is possible to measure significant wind field divergence by numerical differentiation of the wind field data. In this case, we can confirm that there is a microburst present, and issue a microburst warning.

A. THE METHOD

Two methods of divergence are used. Along a line between two stations, linear divergence is estimated. This quantity is a measure of the rate at which an aircraft would lose headwind if it flew along that path; its estimate of the strength of the hazard is most accurate when the center of the microburst lies near that path, and not too near to either of the endpoints. When the microburst center lies well interior to a triangle of stations, then the best estimate of the strength of the hazard is obtained by estimating the 2-dimensional wind field divergence.

The detection threshold must be set differently for each element of a triangulation of the LLWAS network.

B. ALGORITHM SPECIFICATION

1. *Parameters (from geometric configuration file)*

(X(i), Y(i)) – station coordinates in km
edge pointers, direction vectors (p,q), lengths (in km.)
triangle pointers and areas (in $km.^2$)

2. *Input*

$U_2(t,i), V_2(t,i)$ – the double pole filtered wind field components at each of the stations $i = 1, \ldots, n$

3. **Initialization**

During the start up period no triangle computations are done.

4. *Computations for $t > start\_up\_time$*

N.B. the index ordering, (i,j) for edges and (i,j,k) for triangles, must be used as specified in the geometric configuration file.

a) For each edge m (stations i and j), compute the linear divergence

$$\text{edge\_div}(m) = \frac{1}{\text{length}(m)}[(U_2(t,j) - U_2(t,i))\,p(m) + (V_2(t,j) - V_2(t,i))\,q(m)]$$

b) For each triangle m (stations i, j and k), compute the 2-dimensional divergence

$$x_1 = x(j) - x(i), \quad x_2 = x(k) - x(i)$$

$$y_1 = y(j) - y(i), \quad y_2 = y(k) - y(i)$$

$$u_1 = U_2(t,j) - U_2(t,i), \quad u_2 = U_2(t,k) - U_2(t,i)$$

$$v_1 = V_2(t,j) - V_2(t,i), \quad v_2 = V_2(t,k) - V_2(t,i)$$

$$u_x = \frac{y_1 u_2 - y_2 u_1}{2.0 * area(m)}$$

$$v_y = \frac{v_1 x_2 - v_2 x_1}{2.0 * area(m)}$$

$$\text{tri\_div}(m) = u_x + v_y$$

5. *Output*

The lists of divergence values for all network triangles and edges: tri_div, edge-div.

VI. STATION ALARM DETECTION

Combining information from both the Network Mean (NMN) and the Temporal Shear (TS) algorithms we can detect wind shears at stations.

A. THE METHOD

After the initialization period a stable network mean estimate is available, then the data from all stations can tie compared against the current network mean by another Chi-squared test to determine alarms.

$$\frac{[u(t,i)-\bar{u}(t)]^2}{\sigma_u^2(t)} + \frac{[v(t,i)-\bar{v}(t)]^2}{\sigma_v^2(t)} > \text{Alarm Threshold}$$

Since alarms are to be issued only when a hazardous wind shear is detected, the alarm threshold may differ from the trim threshold.

B. ALGORITHM SPECIFICATION

1) Parameters

$\sigma^2_{min} = 4.0$ in $(m/s)^2$
Set-alarm-threshold = 13.0 (unitless)

F – threshold adjustment factor (F=1.5, unitless)
low_lim = 5.0 (unitless)
high_lim = 10.0 (unitless)

2) Input

The residuals and variances for the NMN and TS algorithms,

$R^2_{NMN,u}(t,i),\ R^2_{NMN,v}(t,i) \quad for\ i = 1,\ldots,n$
$R^2_{TS,u}(t,i),\ R^2_{TS,v}(t,i) \quad for\ i = 1,\ldots,n$
$\sigma^2_{NMN,u\gamma}(t),\ \sigma^2_{NMN,v\gamma}(t) \quad for\ i = 1,\ldots,n$
$\sigma^2_{TS,u\gamma}(t),\ \sigma^2_{TS,v\gamma}(t) \quad for\ i = 1,\ldots,n$

3. Initialization $t \le start\_up\_time$

No detections are made during the start up period.

4. Computations for $t > start\_up\_time$

a) Compute the Chi-squared test values for NMN wind shear detections [DETECT]

$$u\_denom = \max\{\sigma^2_{NMN,u\gamma}(t), \sigma^2_{min}\}, \quad v\_denom = \max\{\sigma^2_{NMN,v\gamma}(t), \sigma^2_{min}\}$$

$$\chi^2_{NMN}(i) = \frac{R^2_{NMN,u}(t,i)}{u\_denom} + \frac{R^2_{NMN,v}(t,i)}{v\_denom}$$

b) Set the alarm thresholds

if TS adjustment is used, then for each station $i, i=1, \ldots, n$

$$u\_denom = \max\{\sigma^2_{TS,u\gamma}(t,i),\ \sigma^2_{min}\}$$

$$v\_denom = \max\{\sigma^2_{TS,v\gamma}(t,i), \sigma^2_{min}\}$$

$$\chi^2_{TS}(i) = \frac{R^2_{TS,u}(t,i)}{u\_denom} + \frac{R^2_{TS,v}(t,i)}{v\_denom}$$

$$\text{factor}(i) = \begin{cases} F & \text{if } \chi^2_{TS}(i) < \text{low\_lim} \\ 1 & \text{if low\_ lim} < \chi^2_{TS}(i) < \text{high\_lim} \\ 1/F & \text{if high\_lim} < \chi^2_{TS}(i) \end{cases}$$

alarm-threshold(i) = factor(i) x set-alarm-threshold

c) A station i is in alarm status if

$$\chi^2_{NMN}(i) > \text{alarm-threshold(i)}$$

5. *Output*

The list of stations (if any), in alarm status at this time.

VII. DIVERGENCE ALARM DETECTION

A. THE METHOD

1) Compute the list of stations with high temporal shear values, and the list of stations with low temporal shear values, using the following logical arrays:

$$high\_ts(i) = \{ts(j) > high\_ts\_threshold\}$$

$$low\_ts(i) = \{ts(i) < low\_ts\_threshold\}$$

b) Set the alarm thresholds

if TS adjustment is used, then for each station $i, i=1, \ldots, n$

$$u\_denom = \max\{\sigma^2_{TS,u\gamma}(t,i),\ \sigma^2_{min}\}$$
$$v\_denom = \max\{\sigma^2_{TS,v\gamma}(t,i), \sigma^2_{min}\}$$

$$\chi^2_{TS}(i) = \frac{R^2_{TS,u}(t,i)}{u\_denom} + \frac{R^2_{TS,v}(t,i)}{v\_denom}$$

$$\text{factor}(i) = \begin{cases} F & \text{if } \chi^2_{TS}(i) < \text{low\_lim} \\ 1 & \text{if low\_lim} < \chi^2_{TS}(i) < \text{high\_lim} \\ 1/F & \text{if high\_lim} < \chi^2_{TS}(i) \end{cases}$$

alarm-threshold(i) = factor(i) x set-alarm-threshold

c) A station i is in alarm status if

$$\chi^2_{NMN}(i) > \text{alarm-threshold(i)}$$

5. *Output*

The list of stations (if any), in alarm status at this time.

VII. DIVERGENCE ALARM DETECTION

A. THE METHOD

1) Compute the list of stations with high temporal shear values, and the list of stations with low temporal shear values, using the following logical arrays:

$$high\_ts(i) = \{ts(j) > high\_ts\_threshold\}$$
$$low\_ts(i) = \{ts(i) < low\_ts\_threshold\}$$

1) Parameters

$low\_ts\_threshold$ = 1.5 (unitless)

$high\_ts\_threshold$ = 10.0 (unitless)

$adjust\_$ factor = 0.1 (unitless)

$\sigma^2_{min} = 4.0(in(m/s)^2)$

From geometric configuration file:

edge-thresh(edge) – edge divergence thresholds

tri_thresh(tri) – triangle thresholds

2) Input

The residuals and variances from the TS algorithm,
$R^2_{TS,u}(t,i), R^2_{TS,v}(t,i)$ *for* i = 1, . . . , n
$\sigma^2_{TS,u\gamma}(t), \sigma^2_{TS,v\gamma}(t) \quad for\ i = 1, \ldots, n$

Arrays containing station-edge and station-triangle information, *edges* and *triangles*, respectively.

Arrays containing the triangle and edge divergences, *tri_div* and *edge_div*, respectively.

3) Intialization (for $t < start\_up\_time$)

This method is not implemented during the start-up time.

4. Computations (for $t > start\_up\_time$)

b) Compute the Temporal Shear logical arrays

$$u\_denom = \max\{\sigma^2_{TS,u}(t,i), \sigma^2_{min}\}$$

$$v\_denom = \max\{\sigma^2_{TS,v}(t,i), \sigma^2_{min}\}$$

$$\chi^2_{TS}(i) = \frac{R^2_{TS,u}(t,i)}{u\_denom} + \frac{R^2_{TS,v}(t,i)}{v\_denom}$$

Then for each station i, $i = 1, \ldots, n$, set the logical array values:

$$high\_ts(i) = \{\ \chi^2_{TS}(i) > high\_ts\_threshold\ \}$$

$$low\_ts(i) = \{\ \chi^2_{TS}(i) < low\_ts\_threshold\ \}$$

c) Check Triangles

For each triangle

$n\_high = 0$

$n\_low = 0$

For each triangle vertex find the corresponding stations with high and low temporal shear values:

$stat = triangles(vert, tri)$

if $(high\_ts(stat))$ $\quad n\_high = n\_high + 1$

if $(low\_ts(stat))$ $\quad n\_low = n\_low + 1$

Adjust the triangle divergence thresholds:

if($n\_high > 0$) then

$$tri\_thresh(tri) = tri\_thresh(tri) * (1.0 - n\_high * adjust\_factor)$$

else if $(n\_low > 0)$ then

$$tri\_thresh(tri) = tri\_thresh(tri) * (1.0 + n\_low * adjust\_factor)$$

d) Check Edges

For each edge:

n-high = 0

n-low = 0

For each edge vertex find the corresponding stations with high and low temporal shear values,

$$stat = edges(vert, edge)$$

if($high\_ts(stat)$) $n\_high = n\_high + 1$

if($low\_ts(stat)$) $n\_low = n\_low + 1$

Adjust the edge divergence thresholds:

if(n-high > 0) then

$$edge\_thresh(edge) = edge\_thresh(edge) * (1.0 - n\_high * adjust\_factor)$$

else if($n\_low > 0$) then

$$edge\_thresh(edge) = edge\_thresh(edge) * (1.0 + n\_low * adjust\_factor)$$

e) Compute Divergence Alarms

A triangle m is in alarm status if

$$tri\_div(m) > tri\_thresh(m)$$

Similarly an edge k is in alarm status if

$$edge\_div(k) > edge\_thresh(k)$$

5. *Output*

The list of triangles and/or edges (if any), in alarm status at this time.

VIII. RUNWAY ORIENTED LOSS BY MICROBURST MODELLING

If there is a microburst on the network, an estimate of the runway oriented loss can be provided by applying a symmetric microburst model to the data. Offline analysis provides scaling factors (called *effective lengths*) which converts computed divergences into runway loss estimates. These effective lengths are computed for each individual network element-triangle and edge-and depend upon a triangle's size and shape, and an edge's length.

For each edge vertex find the corresponding stations with high and low temporal shear values,

$stat = edges(vert, edge)$

if($high\_ts(stat)$) $n\_high = n\_high + 1$

if($low\_ts(stat)$) $n\_low = n\_low + 1$

Adjust the edge divergence thresholds:

if($n\_high > 0$) then

$edge\_thresh(edge) = edge\_thresh(edge) * (1.0 - n\_high * adjust\_factor)$

else if($n\_low > 0$) then

$edge\_thresh(edge) = edge\_thresh(edge) * (1.0 + n\_low * adjust\_factor)$

e) Compute Divergence Alarms

A triangle m is in alarm status if

$$tri\_div(m) > tri\_thresh(m)$$

Similarly an edge k is in alarm status if

$$edge\_div(k) > edge\_thresh(k)$$

5. *Output*

The list of triangles and/or edges (if any), in alarm status at this time.

VIII. RUNWAY ORIENTED LOSS BY MICROBURST MODELLING

If there is a microburst on the network, an estimate of the runway oriented loss can be provided by applying a symmetric microburst model to the data. Offline analysis provides scaling factors (called *effective* lengths) which converts computed divergences into runway loss estimates. These effective lengths are computed for each individual network element-triangle and edge-and depend upon a triangle's sire and shape, and an edge's length.

For triangles k associated with runway r
If ($Tri\_est(m) > mb\_rw\_loss(r)$) then
$mb\_rw\_loss(r) = Tri\_est(m)$
For edges m associated with runway r
If ($edge\_est(m) > mb\_rw\_loss(r)$) then
$mb\_rw\_loss(r) = edge\_est(m)$

5) Output

$mb\_rw\_loss(r)$ for $r = 1, \ldots, nr$

IX. RUNWAY ORIENTED LOSS/GAIN USING MAXIMUM DIFFERENCES

This runway component algorithm provides a measure of the estimated windspeed loss or gain along each operational runway.

A. THE METHOD

Given that there is an alarm at an element associated with the specified runway – and no microburst alarm for that runway – compute the runway oriented wind speed loss and gain.

To do so, find the two stations i and j such that P(j) < P(i) and the quantity $W_j - W_i$ is an maximum (gain), 'and the quantity $W_i - W_j$ is a maximum (loss). Where W_k is the runway component wind at station k, given by the dot product of the wind field vector and the runway unit vector: $W_k = (u,v)_k \cdot \hat{N}$. The P(k) array is a list which contains the station numbers– ordered relative to their projections along the runway (in the direction of the unit vector).

B. ALGORITHM SPECIFICATION

1) Parameters (From geometric configuration file)

$\{P(k)\}$, the ordered list of stations associated with this runway.
$\{(N_x, N_y)\}$, the unit vector for this runway.

2) Input at time t

$U_2(t,i), V_2(t,i)$ the double pole filtered wind field values for each of the stations, $i = 1, \ldots, n$

3) Initialization

None is needed for this algorithm.

4) Compute for $t > 0$ [RW_GAIN_ESTIMATE]

a) Compute the runway oriented winds for runway r for the stations k associated with the runway.

$$W(k) = U_2(t,k) * N_x(r) + V_2(t,k) * N_y(r)$$

b) For stations i and j associated with the runway,

$$RW\_GAIN(r) = \max_{P(j)<P(i)} \left\{ W(i) - W(j) \right\}$$

$$RW\_LOSS(r) = \max_{P(j)<P(i)} \left\{ W(j) - W(i) \right\}$$

5) Output

$RW\_GAIN(r)$ and $RW\_LOSS(r)$ for runway r

X. POSSIBLE WINDSHEAR OUTSIDE ALGORITHM

A. THE METHOD

A *Possible Windshear Outside* alarm is issued for a given runway when the designated station(s) at the end of the runway is in alarm status and its wind vector is pointing into the runway.

B. ALGORITHM SPECIFICATION

1) Parameters (From geometric configuration file)

(N_x, N_y), the unit vector for this runway.
The list of designated "end" stations for each runway.

2) Input at time t

$U_2(t,i)$, $V_2(t,i)$ the double pole filtered wind field values for the alarming, designated station, i

$\bar{u}, \bar{v}$, the network mean wind vector.

arrival or departure designation for the given runway.

3) Initialization

None is needed for this algorithm.

4) Compute for $t > 0$ [RW_GAIN_ESTIMATE]

a) Compute the runway oriented winds for runway r for the stations k associated with the runway.

$$W(k) = U_2(t,k) * N_x(r) + V_2(t,k) * N_y(r)$$

b) For stations i and j associated with the runway,

$$RW\_GAIN(r) = \max_{P(j)<P(i)} \left\{ W(i) - W(j) \right\}$$

$$RW\_LOSS(r) = \max_{P(j)<P(i)} \left\{ W(j) - W(i) \right\}$$

5) Output

$RW\_GAIN(r)$ and $RW\_LOSS(r)$ for runway r

X. POSSIBLE WINDSHEAR OUTSIDE ALGORITHM

A. THE METHOD

A *Possible Windshear Outside* alarm is issued for a given runway when the designated station(s) at the end of the runway is in alarm status and its wind vector is pointing into the runway.

B. ALGORITHM SPECIFICATION

1) Parameters (From geometric configuration file)

(N_x, N_y), the unit vector for this runway.
The list of designated "end" stations for each runway.

2) Input at time t

$U_2(t,i), V_2(t,i)$ the double pole filtered wind field values for the alarming, designated station, i
$\bar{u}, \bar{v}$, the network mean wind vector.
arrival or departure designation for the given runway.

B. ALGORITHM SPECIFICATION

1) Parameters (GFI)

The runway alarm association table.

2) Input (at time t)

The list of element alarms at the current time.

3) Initialization

None is needed for this algorithm.

4) Compute for $t >$ start_up_time

a) For the given operational runway r, (*arrival* or *departure*), create the list (indexed on k) of impacted runway sectors from the list of element alarms $\{e\}$ and the association table.

if (ELEMENT_ALARM(e)) then SECTOR-LIST(k) = ASSOCIATION_TABLE(e,r)

b) Given the non-flagged elements of the $SECTOR\_LIST$, the event location is then the maximum or minimum value – for arrival or departure runways respectively. If there art no element alarms associated with the given operational runway the location is given the flag value.

$$LOCATION(r) = \begin{cases} \text{MAX(SECTOR-LIST), if arrival\_rw} \\ \text{MIN(SECTOR-LIST) if departure\_rw} \\ \text{FLAG if no alarm for this runway} \end{cases}$$

5) Output

For the runway r, the location sector of the event (or flag value), $LOCATION(r)$.

XII. RUNWAY ALARM CANCELLATION

There are two situations that can lead to the cancellation of the wind shear alert on a runway. The first is that the estimated loss and gain are both small. The second is that there are no station alarms for this runway, yet the dominant shear is a gain. In each of these cases, the runway alert is completely cancelled. It is not even counted for alarm persistance.

APPENDIX B

DEFINITION OF WINDSHEAR AND ASSOCIATED TERMS

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Windshear is any change in wind speed and/or direction between any two points in space. Windshear, in the aviation context, is a change in the wind along the flight path of the aircraft on a space/time scale of approximately 5,000 to 12,000 feet and 20 to 40 seconds of flight time. Any sustained change of airspeed equal to or greater than 1 kt/sec of flight time is considered a significant windshear. Research has demonstrated that wind changes of this magnitude critically affect aircraft performance. There is a need to use consistent terminology throughout this program and in all the pertinent FAA Orders and other relevant documents. The following meteorological terms are defined:

a. Gust Front. A moving windshift zone separating ambient air from a thunderstorm outflow. Associated with gust fronts are strong updrafts ahead of the front, windshear in the frontal (windshift) zone, and strong turbulence in the frontal zone and above the outflow directly behind the frontal zone. The windshift zone associated with a gust front is typically 0.5 mi in width.

b. Low-Level Windshear. Windshear occurring below 1500 feet AGL along the final approach path or along the takeoff and initial climb-out flight path.

c. Microburst. A small scale (2.5 mi diameter or less) wind event associated with convective activity, characterized by a narrow downdraft creating (when it nears the ground) an outflow spreading horizontally in all directions or in a preferred direction depending upon the horizontal translation of the downward-directed shaft of air. The leading edge of a microburst outflow is a windshift zone (gust front) having a small horizontal radius of curvature and whose boundary is closed. Wet or dry microbursts are distinguished by whether or not rainfall is observed at the ground level in association with the microburst.

d. Outflow (ground level): The primarily horizontal rush of air near the ground originating as a thunderstorm downdraft but turning into the horizontal direction as the downdraft approaches the ground. Outflows from a microburst are confined to a small area and have a closed gust front (circle or ellipse), in contrast to outflows from a squall line which cover a relatively large area and whose gust front is an open surface described by either a nearly straight line or a curve with a large horizontal radius of curvature. Outflows are typically 500 to 3000 feet in depth.

e. Thunderstorm. An atmospheric phenomenon whose existence is determined solely by the presence of lightning or the sound of thunder. In addition to lightning, thunderstorms may produce the following hazards to aviation: strong updrafts and downdrafts, hail, turbulence, restrictions to visibility, microbursts (wet and dry), outflows, gust fronts, windshifts, wind shear, tornadoes, and heavy rain.

f. Windshear (aviation context). Any change in the horizontal wind speed and/or direction between two points in space. Hazardous Windshear (with respect to a moving aircraft) is any sustained (greater than 10 sec) change of true airspeed in excess of 1 knot per second of flight occurring below 1500 feet agl (above ground level).

g. Windshift (aviation context). A moving boundary, straight or curved, representing a transition zone of a sustained change in the horizontal wind speed and/or direction, but primarily the wind direction, often resulting in the need to change active runways. The boundary usually separates air-masses of different temperatures. Windshifts are associated with thunderstorm gust fronts (microburst and straight wind), cold fronts, warm fronts, and seabreeze fronts. The transition zone widths vary from 0.5 mi (gust fronts and some cold fronts) to tens of miles (warm fronts and some cold fronts). All windshifts are characterized by wind shear.

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2.) Runway Descriptions.

Runways are represented in the following terms:

a.) The runway endpoints are expressed in the airport Cartesian coordinate system.

b.) The unit direction vector of the runway is in the direction of use.

c.) The unit normal to the runway is provided.

3.) Element/Runway Association.

A station/edge/triangle is associated with a runway or runway pair (parallel runways), if its barycenter lies within 1.5 Km of the center line of the runway or runway pair (lateral association) and within 1 nautical mile of the ends of the runway corridor (longitudinal association).

Slight variations, no greater than +/- 0.5 km from the association criteria, may be necessary to accommodate specific airport configurations.

4.) Operational Runway Alert Pointer Table

The sector-element associations are based on the assumption that a wind shear is located by the network at the position described by the perpendicular projection from the barycenter of the detecting element with an ambiguity of +/- 2 Km along the runway axis.

Station and runway positions are described relative to an airport Cartesian coordinate system with origin at center field station and the y axis directed to magnetic north for that airport and the x axis directed towards magnetic east. All distances are measured in Km.

a.) An operational runway is a runway with the following characteristics: direction, position, and mode of operation (arrival or departure).

b.) The operational runway corridor is the physical runway and the 3 nautical mile extension in the direction of operation.

c.) There shall be an integer value (0, 1, 2, 3, -99) for each station/edge/triangle and each operational runway, as follows:

1.) **-99:** Element is not associated with this operational runway

2.) **0:** Expected windshear is on the physical runway, based on a windshear detection by this **element(station** /edge /triangle).

3.) **1,2,3:** Distance in nautical miles from the physical runway where wind shear encounter is first expected, based on a wind shear detection by this element (station/edge/triangle)

5.) Priority Stationsand Alternates.

The following are stations that have unique and/or additional functions:

a.) Critical Stations. Critical stations are the stations that provide data for the majority of runways. Failure of any one of these stations may negatively impact the detection, ability of the system dependant on the status of the remaining associated stations for those runways.

b.) Centerfield Station and Alternates. One station is assigned to provide centerfield wind and gust information. In case of failure of the currently assigned **CF** station, a second and third station shall be provided as backups.

c.) Runway Threshold Stations and Alternates. A runway threshold station is the station nearest the end of the physical runway. The wind information reported from this station are the threshold winds for its associated runway. In case of failure of the currently assigned runway threshold station, a second and third station shall be designated as backups.

d.) Network Boundary Stations and Alternates. A network boundary station is one of several stations located on the boundary of the detection network area. Alarms at these stations will be analyzed to determine if there exists a possible windshear condition outside of the detection network area. In case of failure of a currently assigned network boundary station, a second and third station will be designated as backups.

6.) Triangle and Edge Divergence Thresholds.

Triangle and edge divergence thresholds are test values for divergence alarms, chosen to maximize the probability of detection and to minimize false alarms. The units for the thresholds are .001 seconds.

7.) Effective Lengths for Edges and Triangles.

Effective lengths for edges and triangles are scaling factors which are used to convert triangle and edge divergence values into unbiased loss estimates. The units for edges are kilometers.

8.) Predefined Runway Configurations for ATC Displays.

Preprogrammed runway configuration masks will be provided to reflect each local controller position specific to the airport.

9.) Global Constants.

Global constants will not vary from system to system.

1.) Gust Value. The centerfield windspeed is defined as a gust if it exceeds the threshold value. The unit of measure is knots.

2.) Single pole filter constants

3.) Double pole filter constant

4.) Minimum allowed value for the variances

5.) Trim thresholds

6.) Alarm threshold

7.) Initialization values

8.) Persistence

9.) Gain threshold

10.) Adjustment factors

11.) Microburst loss threshold

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3.) Double pole filter constant

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5.) Trim thresholds

6.) Alarm threshold

7.) Initialization values

8.) Persistence

9.) Gain threshold

10.) Adjustment factors

11.) Microburst loss threshold

REQUIREMENTS PARAGRAPH REFERENCE		VERIFICATION LEVEL AND METHOD			
PARA. NO.	TITLE	SUBSYS LEVEL	INTEG LEVEL	SITE LEVEL	REMARKS
3.0	System Requirements.				TITLE
3.1	Definition.				DEFINITION
3.1.1	Functional Areas				DEFINITION
3.1.2	Operational Requirements	•			LEAD-IN
A.		L	X	X	
B.		L	X	X	
C.		L	X	X	
D.		L	X	X	
E.		L	X	X	
F.		L	X	X	
3.1.3	Equipment Configuration				LEAD-IN
3.1.3.1	Existing Equipment	I	X	X	
3.1.3.2	New or Additional Equipment	L	L	L	
3.2	Characteristics				LEAD-IN
A.					LEAD-IN
A.1		L	X	X	
A.2		L	X	X	
B.					LEAD-IN
B.1		L	X	X	
B.2		L	X	X	
C.					LEAD-IN
C.1		L	X	X	
C.2		L	X	X	
3.2.1	Performance Characteristics				LEAD-IN
3.2.1.1	Real Time State				TITLE
A.		T	D	X	
B.		L	X	X	
B.1		T	X	X	
B.2		T	X	X	
3.2.1.1.1	Normal Mode	L	L	X	
A.		T	T	X	
B.		T	T	X	
C.		T	T	X	
D.		D	X	X	
E.		D	X	X	
3.2.1.1.1.1	Data Collection.	D	D	X	
A.		D	X	X	
B.		A	X	D	
C.		A/D	D	X	
D.		D	D	X	
3.2.1.1.1.1.1	Data Input.	T	D	X	
3.2.1.1.1.1.1.1	Wind Data	T	D	X	
A.		T	X	X	
B.		T	X	X	
C.		T	X	X	
3.2.1.1.1.1.1.2	Scan Cycle.				DEFINITION

VERIFICATION METHODS: T=TEST, D=DEMONSTRATION, A=ANALYSIS, I=INSPECTION,
L=VERIFIED BY LOWER LEVEL RQMT, X=NOT REWIRED/APPLICABLE

REQUIREMENTS PARAGRAPH REFERENCE PARA. NO.	TITLE	VERIFICATION LEVEL AND METHOD SUBSYS LEVEL	INTEG LEVEL	SITE LEVEL	REMARKS
3.0	System Requirements.				TITLE
3.1	Definition.				DEFINITION
3.1.1	Functional Areas				DEFINITION
3.1.2	Operational Requirements	•			LEAD-IN
A.		L	X	X	
B.		L	X	X	
C.		L	X	X	
D.		L	X	X	
E.		L	X	X	
F.		L	X	X	
3.1.3	Equipment Configuration				LEAD-IN
3.1.3.1	Existing Equipment	I	X	X	
3.1.3.2	New or Additional Equipment	L	L	L	
3.2	Characteristics				LEAD-IN
A.					LEAD-IN
A.1		L	X	X	
A.2		L	X	X	
B.					LEAD-IN
B.1		L	X	X	
B.2		L	X	X	
C.					LEAD-IN
C.1		L	X	X	
C.2		L	X	X	
3.2.1	Performance Characteristics				LEAD-IN
3.2.1.1	Real Time State				TITLE
A.		T	D	X	
B.		L	X	X	
B.1		T	X	X	
B.2		T	X	X	
3.2.1.1.1	Normal Mode	L	L	X	
A.		T	T	X	
B.		T	T	X	
C.		T	T	X	
D.		D	X	X	
E.		D	X	X	
3.2.1.1.1.1	Data Collection.	D	D	X	
A.		D	X	X	
B.		A	X	D	
C.		A/D	D	X	
D.		D	D	X	
3.2.1.1.1.1.1	Data Input.	T	D	X	
3.2.1.1.1.1.1.1	Wind Data	T	D	X	
A.		T	X	X	
B.		T	X	X	
C.		T	X	X	
3.2.1.1.1.1.1.2	Scan Cycle.				DEFINITION

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REQUIREMENTS PARAGRAPH REFERENCE		VERIFICATION LEVEL AND METHOD			
PARA. NO.	TITLE	SUBSYS LEVEL	INTEG LEVEL	SITE LEVEL	REMARKS
C.		D	D	D	
D.		D	D	D	
E.		D	D	D	
F.		D	X	X	
G.		D	D	D	
3.2.1.1.1.3.1	Storage Capacity	D	X	X	
3.2.1.1.1.3.2	Tape Backup	I/A	X	X	
A.		A	X	X	
B.		D	X	X	
C.		D	X	X	
3.2.1.1.1.4	ATC Display.	I	I	I	
3.2.1.1.1.4.1	General Characteristics				TITLE
A.		I	X	X	
B.					TITLE
B.1		I	I	I	
B.2		D/I	D/I		
3.2.1.1.1.4.2	Type 1 Displays	I	I	I	
3.2.1.1.1.4.2.1	Maximum Quantity of Type 1 Displays	D	X	X	
3.2.1.1.1.4.2.2	Alphanumeric Displays	I	X	X	
3.2.1.1.1.4.2.3	Physical Constraints				(LEAD-IN
A.		I	X	X	
B.		I	X	X	
3.2.1.1.1.4.2.4	Configuration Screens				LEAD-IN
A.		I	I	I	
B.		I	I	I	
C.		I	D	D	
3.2.1.1.1.4.2.5	Display Format	I	X	X	
IA-		L	X	X	
		D	X	X	
;:::		D	X	X	
A.3		D	X	X	
B.		D	X	X	
B.1		D	D	X	
B.2		D	D	X	
C.		D	D	D	
D.		D	X	X	
E.					LEAD-IN
E.1		D	D	D	
E.2		D	D	D	
3.2.1.1.1.4.2.5.1	Non-Alert Status.				LEAD-IN
A.		D	D	D	
B.		L	X	X	
B.1		D	D	D	
B.2		D	D	D	
3.2.1.1.1.4.2.5.2	Alert Status	D	X	X	
A.		D	X	X	

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REQUIREMENTS PARAGRAPH REFERENCE PARA. NO.	TITLE	VERIFICATION LEVEL AND METHOD SUBSYS LEVEL	INTEG LEVEL	SITE LEVEL	REMARKS
B.		T	X	X	
C.					LEAD-IN
		●	D	X	
:::		D	D	X	
C.3		D	D	X	
C.4		D	D	X	
C.5		T	D	D	
D.		D	X	X	
E.		D	D	X	
F.		T	D	X	
3.2.1.1.1.4.2.6	Brightness and Contrast Controls	D	D	D	
3.2.1.1.1.4.3	Type 2 Display	I	I	I	
3.2.1.1.1.4.3.1	Physical Constraints	I	X	X	
3.2.1.1.1.4.3.2	Maximum Quantity of Type 2 Displays	D	X	X	
3.2.1.1.1.4.3.3	Display Format	D	X	X	
3.2.1.1.1.5	Remote Monitoring S&system	L	X	X	
A.		T	X	X	
B.		A/D	X	X	
3.2.1.1.1.5.1	Categories of Operation	T	X	X	
A		T	D	X	
B		T	D	X	
3.2.1.1.1.5.2	RMS Organization	T	X	X	
3.2.1.1.1.5.3	RMS Functions	T	X	X	
3.2.1.1.1.5.3.1	Monitoring	T	D	X	
A.		T	D	X	
3.2.1.1.1.5.3.2	Report Generation	T	D	X	
A.		T	D	X	
B.		T	D	X	
C.		T	D	X	
D.		T	D	X	
3.2.1.1.1.5.3.3	Failure Detection and Reporting	T	D	X	
A.		T	D	X	
B.		T	D	X	
C.		T	D	X	
D.		T	D	X	
E.		T	D	X	
3.2.1.1.1.5.3.4	System Control	T	D	X	
A-		T	D	X	
		T	D	X	
;:::		T	D	X	
A.3		T	D	X	
A.4		T	D	X	
B.		T	D	X	
3.2.1.1.1.5.3.5	Remote Station Diag. & Fault Isol.	T	D	X	
A.		T	D	X	
B.		T	D	X	

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REQUIREMENTS PARAGRAPH REFERENCE		VERIFICATION LEVEL AND METHOD			
PARA. NO.	TITLE	SUBSYS LEVEL	INTEG LEVEL	SITE LEVEL	REMARKS
B.		T	X	X	
C.					LEAD-IN
		●	D	X	
:::		D	D	X	
C.3		D	D	X	
C.4		D	D	X	
C.5		T	D	D	
D.		D	X	X	
E.		D	D	X	
F.		T	D	X	
3.2.1.1.1.4.2.6	Brightness and Contrast Controls	D	D	D	
3.2.1.1.1.4.3	Type 2 Display	I	I	I	
3.2.1.1.1.4.3.1	Physical Constraints	I	X	X	
3.2.1.1.1.4.3.2	Maximum Quantity of Type 2 Displays	D	X	X	
3.2.1.1.1.4.3.3	Display Format	D	X	X	
3.2.1.1.1.5	Remote Monitoring S&system	L	X	X	
A.		T	X	X	
B.		A/D	X	X	
3.2.1.1.1.5.1	Categories of Operation	T	X	X	
A		T	D	X	
B		T	D	X	
3.2.1.1.1.5.2	RMS Organization	T	X	X	
3.2.1.1.1.5.3	RMS Functions	T	X	X	
3.2.1.1.1.5.3.1	Monitoring	T	D	X	
A.		T	D	X	
3.2.1.1.1.5.3.2	Report Generation	T	D	X	
A.		T	D	X	
B.		T	D	X	
C.		T	D	X	
D.		T	D	X	
3.2.1.1.1.5.3.3	Failure Detection and Reporting	T	D	X	
A.		T	D	X	
B.		T	D	X	
C.		T	D	X	
D.		T	D	X	
E.		T	D	X	
3.2.1.1.1.5.3.4	System Control	T	D	X	
A-		T	D	X	
		T	D	X	
;:::		T	D	X	
A.3		T	D	X	
A.4		T	D	X	
B.		T	D	X	
3.2.1.1.1.5.3.5	Remote Station Diag. & Fault Isol.	T	D	X	
A.		T	D	X	
B.		T	D	X	

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REQUIREMENTS PARAGRAPH REFERENCE		VERIFICATION LEVEL AND METHOD			
PARA. NO.	TITLE	SUBSYS LEVEL	INTEG LEVEL	SITE LEVEL	REMARKS
A.		D	X	X	
3.2.1.1.3.2.1	Hazardous US Detection Analysis.	T	X	X	
A.		.			DEFINITION
B.					DEFINITION
C.					DEFINITION
D.					DEFINITION
D.1					DEFINITION
D.2					DEFINITION
3.2.1.1.3.2.2	Runway Element Alarm Generation.	D	X	X	
3.2.1.1.3.2.2.1	Runway Message.	D	X	X	
A.		D	X	X	
B.		D	X	X	
3.2.1.1.3.3	ATC Display.	D	X	X	
3.2.1.1.3.3.1	Representation of Unavailable Data.	D	X	X	
A.		D	X	X	
3.2.1.1.3.3.2	Clear Displays	D	X	X	
3.2.1.1.3.3.3	System Status Line	D	X	X	
A.		D	X	X	
B.		D	X	X	
C.		D	X	X	
3.2.1.1.3.4	Remote Monitoring Subsystem	D	X	X	
3.2.1.2	System Support State.				TITLE
A-		L	X	X	
		D	X	X	
;:::		D	X	X	
B.		L	X	X	
B.1		D	X	X	
B.2		D	X	X	
C.		D	X	X	
D.		D	X	X	
3.2.1.2.1	Modes of Operation	D	D	D	
A.		D	D	D	
B.		D	D	D	
3.2.1.2.2	RMS Capabilities	D	X	X	
A.		D	X	X	
B.		D	X	X	
3.2.1.2.2.1	Dis. & Mod. S/W Main. Parameters	D	X	X	
3.2.1.2.2.2	Test Functions	D	X	X	
A.		D	X	X	
B.		D	X	X	
3.2.1.2.2.3	Adjusting Maintenance Alarm Ranges	D	X	X	
3.2.1.2.2.4	Diagnostics	D	X	X	
3.2.1.2.2.5	Testing of All Remote Stations	D	D	X	
A.		D	D	X	
B.		D	D	X	
C.		D	D	X	

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REQUIREMENTS PARAGRAPH REFERENCE		VERIFICATION LEVEL AND METHOD			
PARA. NO.	TITLE	SUBSYS LEVEL	INTEG LEVEL	SITE LEVEL	REMARKS
3.2.1.2.3	System Console	D	X	X	
3.2.1.2.3.1	System or Incident Analysis	D	X	X	
3.2.1.2.3.1.1	Event Reconstruction	D	X	X	
A.		D	X	X	
B.		D	X	X	
B.1		D	X	X	
B.2		D	X	X	
3.2.1.2.3.1.2	System Performance Summary	D	X	X	
3.2.1.2.3.2	Adj. Operational Alarm Ran.	D	X	X	
3.2.1.2.3.3	Dis. & Mod. S/W Op. Perimeters	D	X	X	
3.2.2	System Capability Relationships				TITLE
3.2.2.1	Real Time Capabilities	D	X	X	
3.2.2.2	System Support Capabilities	D	X	X	
3.2.3	External Interfaces				DEFINITION
A.		L	L	X	
B.		L	L	X	
		L	L	X	
I::		L	L	X	
E.		L	L	X	
IF-		L	L	X	
		L	L	X	
;,":,.,.,	LLWAS to MPS Interface.	T	T	X	
A.		T	T	X	
B.		T	T	X	
		T	T	X	
Is:,.,.,	LLWAS to RMSC Interface.	T	T	X	
3.2.3.3	LLWAS to TCCC Interface.	T	T	X	
A.		T	T	X	
B.		T	T	X	
3.2.3.4	LLWAS to MDT Interface.	T	T	X	
3.2.3.5	LLWAS to TDWR Interface.	T	T	X	
3.2.3.6	LLWAS to External Time.	T	T	X	
3.2.3.7	LLWAS to Pole Mounts for Remote Sensors	I	D	D	
3.2.4	Physical Characteristics.				TITLE
3.2.4.1	Weight Limits.	I	X	X	
3.2.4.2	Dimensional Limits.	I	X	X	
3.2.4.3	Durability.	I	X	X	
3.2.5	System Quality Factors.				TITLE
3.2.5.1	Reliability.	A	X	X	
3.2.5.2	Maintainability.	A	X	X	
3.2.5.3	Additional Quality Factors.	X	X	X	
3.2.6	Environmental conditions.				TITLE
3.2.6.1	Sensor Environmental Requirements.	I	X	X	
3.2.6.1.1	Water Penetration.	I	X	X	
3.2.6.1.2	Lightning Protection.	I	X	X	
3.2.6.1.3	Icing.	I	X	X	

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REQUIREMENTS PARAGRAPH REFERENCE		VERIFICATION LEVEL AND METHOD			
PARA. NO.	TITLE	SUBSYS LEVEL	INTEG LEVEL	SITE LEVEL	REMARKS
3.2.1.2.3	**System Console**	D	X	X	
3.2.1.2.3.1	System or Incident Analysis	D	X	X	
3.2.1.2.3.1.1	Event Reconstruction	D	X	X	
A.		D	X	X	
B.		D	X	X	
B.1		D	X	X	
B.2		D	X	X	
3.2.1.2.3.1.2	System Performance Summary	D	X	X	
3.2.1.2.3.2	Adj. Operational Alarm Ran.	D	X	X	
3.2.1.2.3.3	Dis. & Mod. S/W Op. Perimeters	D	X	X	
3.2.2	System Capability Relationships				TITLE
3.2.2.1	Real Time Capabilities	D	X	X	
3.2.2.2	System Support Capabilities	D	X	X	
3.2.3	External Interfaces				DEFINITION
A.		L	L	X	
B.		L	L	X	
		L	L	X	
I::		L	L	X	
E.		L	L	X	
IF-		L	L	X	
		L	L	X	
;,":,.,.,	LLWAS to MPS Interface.	T	T	X	
A.		T	T	X	
B.		T	T	X	
		T	T	X	
Is:,.,.,	LLWAS to RMSC Interface.	T	T	X	
3.2.3.3	LLWAS to TCCC Interface.	T	T	X	
A.		T	T	X	
B.		T	T	X	
3.2.3.4	LLWAS to MDT Interface.	T	T	X	
3.2.3.5	LLWAS to TDWR Interface.	T	T	X	
3.2.3.6	LLWAS to External Time.	T	T	X	
3.2.3.7	LLWAS to Pole Mounts for Remote Sensors	I	D	D	
3.2.4	Physical Characteristics.				TITLE
3.2.4.1	Weight Limits.	I	X	X	
3.2.4.2	Dimensional Limits.	I	X	X	
3.2.4.3	Durability.	I	X	X	
3.2.5	System Quality Factors.				TITLE
3.2.5.1	Reliability.	A	X	X	
3.2.5.2	Maintainability.	A	X	X	
3.2.5.3	Additional Quality Factors.	X	X	X	
3.2.6	Environmental conditions.				TITLE
3.2.6.1	Sensor Environmental Requirements.	I	X	X	
3.2.6.1.1	Water Penetration.	I	X	X	
3.2.6.1.2	Lightning Protection.	I	X	X	
3.2.6.1.3	Icing.	I	X	X	

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REQUIREMENTS PARAGRAPH REFERENCE		VERIFICATION LEVEL AND METHOD			
PARA. NO.	TITLE	SUBSYS LEVEL	INTEG LEVEL	SITE LEVEL	REMARKS
3.5.3.3	Hardware Mod. Support	D	D	D	
3.5.4	Supply	D	D	D	
3.6	Training.				TITLE
3.7	Characteristics of Subordinate Elements.	X	X	X	
3.8	Precedence.	X	X	X	
3.9	Qualification.	X	X	X	
3.9.1	Philosophy of Testing.	X	X	X	
3.9.2	Location of Tests.	X	X	X	
3.9.3	Qualification Methods.	X	X	X	
3.9.3.1	Test.	X	X	X	
3.9.3.2	Demonstration.	X	X	X	
3.9.3.3	Analysis.	X	X	X	
3.9.3.4	Inspection.	X	X	X	
3.9.4	Test Levels.	X	X	X	
3.9.4.1	Subsystem.	X	X	X	
3.9.4.2	Integration.	X	X	X	
3.9.4.3	Site.	X	X	X	
3.9.4.4	Verification Categories	X	X	X	
3.9.4.4.1	DT&E	X	X	X	
3.9.4.4.2	OT&E	X	X	X	
3.9.4.4.3	PAT&E	X	X	X	
3.9.5	Formal Tests.	X	X	X	
3.9.5.1	Detection Performance Tests				
3.9.6	Formal Test Constraints.	X	X	X	
3.9.7	External Eqip. Envir. Tests				
3.10	Standard Sample.	X	X	X	
3.11	Prod. Sample, Per. Prod. Sample, Pilot, or Pilot Lot	X	X	X	
3.12	Software Development				TITLE
3.12.1	Programming Languages	I	X	X	
3.12.1.1	Unit Attributes.	I	X	X	
A.		I	X	X	
B.		I	X	X	
C.		I	X	X	
D.		I	X	X	
E.		I	X	X	
F.		I	X	X	
G.		I	X	X	
H.		I	X	X	
I.		I	X	X	
J.		I	X	X	
K.		I	X	X	
L.		L	X	X	
M.		L	X	X	
N.		I	X	X	
O.		I	X	X	
3.12.2	Operability	T	D	D	

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REQUIREMENTS PARAGRAPH REFERENCE		VERIFICATION LEVEL AND METHOD			
PARA. NO.	TITLE	SUBSYS LEVEL	INTEG LEVEL	SITE LEVEL	REMARKS
5.0	Prepsration for Delivery	I	X	X	
5.1	Pack. Req. for System Equip.	I	X	X	
5.1.1.1	Site Stocks and Workcenter Stocks	I	X	X	
5.1.1.2	Depot Stocks	I	X	X	
A.		I	X	X	
B.		I	X	X	
5.1.2	Marking	I	X	X	
5.1.3	Pecking Req. for Software	I	X	X	

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FAA-E-2697A
March 6, 1989

U.S. Department of Transportation

Federal Aviation Administration

Specification

Low-Level Wind Shear Alert System